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A SHORT FORM OF THE KEIRSEY TEMPERAMENT SORTER TO PREDICT SUCCESS IN AN INTRODUCTORY ACCOUNTING COURSE

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ABSTRACT

This study examines the relationship between specific questions in the Keirsey Temperament Sorter personality preferences test and performance in an entry level accounting course. It develops a structural equation model linking specific questions in the Keirsey Temperament Sorter personality preferences test to grades obtained by majors in business disciplines other than accounting who were enrolled in an introductory accounting course at one mid-sized, public university. The results demonstrate that six (6) questions in the Keirsey Temperament Sorter are significantly related to prediction of success in the introductory accounting course. Specifically, questions that indicated a *sensing* personality preference for how a student gathers information proved to be significantly related to the grade that an individual attained in the introductory accounting course.

Professors who teach the introductory accounting course may elect to take a few minutes to administer these six questions at the beginning of their first class period. Students who, through their responses to these six questions, demonstrate a low aptitude for accounting could then be advised that accounting may not come easily for them and then be counseled as to what steps they may need to take in order to succeed in the course.

INTRODUCTION

Historically, specific aptitudes demonstrated by certain individuals have been ascribed to their unique personality types. For instance, most individuals would accept the premise that certain members of society possess a unique aptitude for music.

Previous work by Jackson and Lawty-Jones [7] and Honey and Mumford [6] have linked learning styles to a student's personality, although Loo [10] pointed out that learning styles and personality are not actually the same constructs. While a significant body of research exists concerning the relationship of student learning styles to academic performance, far less has been written about the relationship between student personality type and classroom performance.

This study investigates the premise that specific questions in a personality test predict academic performance in a specific academic discipline: accounting.

BACKGROUND

The theory that individuals exhibit specific personality types was introduced by Carl Gustav Jung in his book *Psychological Types* in 1921. In his book, Jung documented a set of typical

differences in the human psyche that he termed "introverted" and "extroverted." He posited that extroverted individuals prefer the outer world of people and things while introverted individuals prefer the inner world of ideas and concepts. Jung also posited that psychological types were related to certain basic psychological functions which he termed thinking, feeling, sensation, and intuition [16].

Jung's descriptions of introversion and extroversion represent the extremes of human behavior. Each individual will actually display a tendency to lean more in the direction of introversion or extroversion but possess both qualities to some degree. In actuality, each individual possesses all of the attributes of sensation, thinking, feeling, and intuition, but demonstrates a predisposition to rely on some attributes more than others. The individual's predisposition toward individual attributes determines their specific personality type.

In 1936, Jung published a related paper that he described as an appendix to his original book, *Psychological Types*. In that paper, he described in greater detail his four basic psychological types: thinking, feeling, sensation, and intuition. He proposed that sensation establishes that something exists, thinking establishes what it means, feeling attaches a value to it, and intuition determines when it comes and whether it will last [16].

It has been postulated that individuals perceive their environment through either a sensing or an intuitive paradigm [15]. Sensing types tend to organize input sequentially, in a step-by-step process. Conversely, intuitive types start with a top down view of broad concepts. They then take these abstract concepts and organize them as a more workable general framework. Intuitive types also tend to dislike activities that are detail oriented.

On the other hand, an individual's decision making processes are dominated by either thinking or feeling. Those individuals who conform to the thinking type definition tend to use a logical, objective decision process, while those who resemble the feeling type are inclined to use a value-based or subjective process which puts more emphasis on how the decision will impact others [15].

Finally, an individual's attitude toward their external environment and the structure of their everyday living is dominated by judging or perceiving. Those individuals who conform to the judging-type definition prefer to plan ahead and prefer closure and the settling of things. Those individuals who conform to the perceiving-type definition prefer to postpone decisions and keep things open-ended.

Jung also drew some notable caveats regarding psychological typing. First, the basic typologies of introversion, extroversion, sensation, thinking, feeling, and intuition were never intended to encompass all aspects of human personality. Furthermore, the purpose of psychological typing is not to classify people into neat, restrictive categories. He maintained that simply categorizing individuals, in it's self, would be a meaningless exercise. Jung believed that psychological typing merely provided the methodology for conducting empirical research by providing points of view and guidelines that reduce the plethora of individual personality types down to a manageable array. In addition, psychological typing may aid us in understanding the broad differences in personality and personal preferences that occur among individuals [16].

HYPOTHESIS

Hypotheses: H1 Specific questions in a personality test do not predict performance in an introductory accounting course.

THE RESEARCH INSTRUMENT

Research into the area of learning styles has been ongoing for many years. This has resulted in the development of over twenty different currently available models [4] [14] [5].

Much of the previous research into the link between personality type and accounting has been based on the Myers-Briggs Type Indicator (MBTI). This is a formal preferences based survey instrument consisting of over 120 questions designed to access an individual's personality preferences in four primary areas: introvert/extrovert, sensing/intuitive, thinking/feeling, and judging/perceiving. In theory, every individual has a predisposed preference to one of each of the above pairs. Thus, there is a potential of sixteen (four squared) individual personality types and, theoretically, each individual can be categorized as one of those types.

Wheeler [17] found 16 published accounting research articles using the MBTI instrument. Of the 16 articles, four examined the relationship between academic performance of accounting students and their indicated MBTI personality type. Specifically, Ott, et al. [13] found that individuals categorized as sensing (S) and thinking (T) performed better, as measured by course grades, in courses using the lecture method.

Utilizing the MBTI instrument, Nourayi and Cherry [11] examined the relationship between the performance of several students in seven different accounting courses and their individual personality preferences. The only significant relationship found was that students categorized as sensing (S) outperformed intuitive (I) students in three (Tax, Auditing and Intermediate II) of the seven courses analyzed in their study.

While not examining the linkage between personality type and course grade, Landry et al. [9] focused on computer usage and the MBTI personality of accounting students. They found that the STJ-preference (sensing, thinking, judging) personality type was over represented, comprising 42% of their entire sample, with ISTJ (introverted STJ's) comprising 17% and ESTJ (extroverted STJ's) comprising 25% respectively.

Oswick and Barber [12] examined the MBTI personality preferences of undergraduate non-accounting majors and contrasted the individual findings to each student’s performance in an introductory accounting course, as measured by course grades. They found that there were no statistically significant correlations between indicated personality preference and performance.

Keirsey and Bates developed their own independent personality preferences test utilizing the same 16 personality types as the MBTI instrument. Since its inception, the Keirsey Temperament Sorter (KTS) has grown to become the most widely used personality inventory measuring tool in the world, surpassing even the MBTI instrument [8].

The authors have chosen to use the KTS instrument in their research for several reasons. First, the 16 resulting personality classifications used by the KTS instrument correspond directly to those of the MBTI instrument that had been used in the previous research conducted in the field. Second, it can be administered and scored by the researchers in approximately twenty minutes without having to send the instrument off site. In addition, the authors have complete access to the individuals' responses to each question, not just their overall personality type score. This has proved to be invaluable in facilitating a far more detailed analysis of the results. Finally, the cost of administering the MBTI instrument to several hundred students proved to be prohibitive while the cost of administering the KTS instrument fell within the researchers' budget constraints.

The authors' exploratory research, as described in this paper, matched that of Nourayi and Cherry [11] and revealed that only the sensing (S) and intuitive (I) dimensions were significant (at the 10 % level) with respect to success in the introductory accounting course. Accordingly, the authors' selected the twenty questions in the KTS instrument that measure sensing (S) or intuitive (I) preferences as possible indicators of success in the introductory accounting course.

METHODOLOGY

The authors administered the KTS instrument to 79 business majors enrolled in the basic financial accounting course for non-accounting majors. To motivate the students to conscientiously complete the survey, it was administered during a normal class period. In addition, the students were informed that they could receive access to their individual personality profiles, as well as a copy of a common careers list for each personality type, simply by contacting the faculty member who administered the survey instrument. They were also told to leave the questionnaire blank if they chose not to participate. No blank forms were received. The data was coded centered on zero so that the primary area of interest sensing/intuitive could be measured with one variable.

In compliance with university policy, the research was pre-approved by the University's Institutional Review Board and the students were informed that, although their individual results would remain strictly confidential, aggregated research results would be included in various future research findings made public by the authors.

RESULTS

Because the authors had access to the responses provided by each individual who had completed the KTS instrument, it was possible to determine the relative strength of each personality preference recorded by the individual students. In addition, it was possible to access university records to determine the individual grade earned by each student in their introductory accounting course. Given the availability of such detailed information, it was decided that the possible correlation between the strength of a student's specific personality preferences and the letter grade they received in their introductory accounting course could be examined.

Primary Analysis

The model was tested with latent variable structural equation analysis using the AMOS [1] computer program. This type of analysis has been used by other researchers to investigate

Keirsey-type personality measures [3]. This analysis combined the proposed structural model specifying relationships between the latent variable of interest with a measurement model that specifies relationships between the latent variable and the observed variables (i.e., individual questionnaire items) used to measure them. This approach adjusts the coefficients of the paths between the variables of interest in the structural model for the effects of random measurement error.

Only six questions were found to be significant: They were the third, sixth, ninth, 12th, 17th, and 19th questions that comprise the Sensing/Intuitive dimension of the Keirsey Temperament Sorter. These questions correspond to question numbers 9, 17, 30, 38, 58 and 65 of the Keirsey Temperament Sorter Instrument itself [8, pp. 4-9]. They are:

9. Are you more
   _____ (a)sensible than ideational
   _____ (b) ideational than sensible

17. Do you like writers who
   _____ (a) say what they mean
   _____ (b) use metaphors and symbolism

30. Common sense is
   _____ (a) usually reliable
   _____ (b) frequently questionable

38. Do you speak more in
   _____ (a) particulars than generalities
   _____ (b) generalities than particulars

58. Do you prize in yourself
   _____ (a) a strong hold on reality
   _____ (b) a vivid imagination

65. In stories do you prefer
   _____ (a) action and adventure
   _____ (b) fantasy and heroism

[*Response (a) for each of the above questions indicates a sensing preference while response (b) indicates an intuitive preference.*]

As is perhaps not surprising, given the large number of factors that were not significant, the model as a whole did not have acceptable fit, and the path between the sensing (S) or intuitive (I) preference and success in the introductory accounting course was not significant.

Chi-square and the root mean square error of approximation (RMSEA) were used to assess the overall fit of the model to the data. Chi-square (X^2 [21] = 23.272, p = .056) of the proposed model was not significant. Because chi-square is really a "badness" of fit measure, this non-significant value suggests that the model had an acceptable fit to the data. The RMSEA, which was .064, is below the .08 upper bound that Brown and Cudeck [2] suggested represents reasonable model fit. On the whole, the fit indices indicate that the model had an acceptable fit to the data from a practical standpoint. Thus we can reject our original hypothesis and conclude that a specific combination of personality questions can predict success in an introductory accounting course.

IMPLICATIONS

Researchers have long been interested in the notion that certain students seem to naturally possess the personality traits that make them more suited to success in accounting courses.

Presented herein is a short form (six questions) of the Keirsey Temperament Sorter that appears to be casually related to success in accounting courses. Professors who teach the introductory accounting course may elect to take a few minutes to administer these six questions at the beginning of their first class period. Students who, through their responses to these six questions, demonstrate a low aptitude for accounting could be advised that accounting may not come easily for them and then be counseled as to what steps they may need to take in order to succeed in the course. Such counseling may not only help the student succeed, but also may help the instructor succeed since the instructor would be able to identify a student who may need extra attention and assistance as soon as the semester starts.

A second application of this short index occurs when prospective students are beginning their college careers. Many times a student will indicate to a department chair or faculty member that they have an interest in becoming an Accounting major but aren't quite sure that it is the major for them. If a concise temperament survey instrument were available, the Chair or faculty member could quickly determine whether the perspective student demonstrates an aptitude for accounting. If so, the student could be counseled that accounting could be a viable career path. If no aptitude for accounting was demonstrated, the perspective student could be cautioned that they may have to work extra hard in order to succeed. Hence, the short temperament survey would be another tool at the disposal of anyone who is advising business students about potential career paths.

SUMMARY AND FUTURE RESEARCH

This paper presents a short form of the KTS temperament sorter that is designed to determine whether students are predisposed to having an "aptitude for accounting" and to achieving success in an introductory accounting course.

These questions are numbers 9, 17, 30, 38, 58 and 65 in the Keirsey Temperament Sorter which were presented in their entirety previously [8]. Choosing response (a) to each of these questions would indicate a strong aptitude for accounting coursework while selection of response (b) for all of the questions would indicate an extremely low aptitude for accounting related topics.

To lend credence to this finding, the research needs to be replicated utilizing larger numbers of students enrolled in introductory accounting courses at several different universities of diverse sizes as well as within business colleges with varying reputations regarding the quality and rigor of their programs.

Finally, if a statistically significant number of observations could be amassed, relationships between all 70 KTS questions and performance in accounting courses should be examined.

References available upon request from Richard L Baker.

AN INTRODUCTION TO THE FINANCIAL ACCOUNTING RESEARCH SYSTEM (FARS) DATABASE

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ABSTRACT

The CPA Examination consists of multiple choice and simulations. The simulations require the candidate to research professional databases to locate authoritative pronouncements and apply their findings. Familiarity with the structure and content of those databases should aid candidates in passing the Exam. One such database is the Financial Accounting Research System (FARS). This paper relates a brief background, describes the categories of the FARS contents, and discusses current texts/cases using FARS. It then provides excerpts from exercises appropriate for beginning Intermediate Accounting students to explore the contents of FARS and learn to perform queries to retrieve relevant information.

INTRODUCTION

In an effort to update the content and delivery of the CPA Exam, a series of improvements were implemented throughout the early 2000s. The exam began to be administered online and is now taken in separate sections rather than the previous requirement that a candidate sit for all unpassed parts. Another innovation was the inclusion of questions requiring answers obtained through contemporary research. Candidates access various databases during their examination, search for relevant sections or subsections that address the question at hand, and cut and paste their answers onto the exam.

Each of the databases has slightly different searchable characteristics. Arguably, candidates will be best served by having had previous exposure to and practice with the databases. In her book, "You Can Pass the CPA Exam," Debra Hopkins [3] has stated "No one should set foot in a …test center until he/she has spent considerable time practicing the navigational format of the various search routines."

The audit and attestation portion of the exam will direct candidates to the AICPA Professional Standards, for the tax/regulation portion of the exam will allow students to access a version of the Tax Code, and for financial accounting/reporting they will access Accounting Standards via The Financial Accounting Research System (FARS). FARS is the official searchable database used to research financial accounting questions.

THE FARS DATABASE

This section discusses the various options available to access the FARS database. It then lists the contents and discusses various ways to practice using the system.

Access

The Financial Accounting Standards Board (FASB) web site fasb.org has the full text of all of the FASB pronouncements. The format used at this site does not follow the same search protocol as the Exam, nor does it go back prior to 1973, nor is it noted which sections have been subsequently superseded. Thus, students may practice their skills in identifying key terms for their searches, but they will not know if their results still constitute GAAP.

Wiley Publishing has had exclusive distribution rights to the Financial Accounting Standards Board (FASB) materials, including the FARS. The material here is all-inclusive and coded in a way that allows users to know if the section they are reading has been superseded. It also has several unique search characteristics.

To date, student access has been achieved in one of three ways:

- A network version accessible to 15 users simultaneously, currently lists for $2,000/year.
- The CD version packaged along with another Wiley title for $30.95.
- The CD version sold separately for $30.95

Descriptions of the CD version and aids to help students use the data base are available from at least two universities. Babson's website offers an introduction and help topics at: http://www3.babson.edu/Library/electronic_resources/fars.cfm and Western Washington University's web site offers a version of the CDs instructions at: http://www.library.wwu.edu/ref/subjects/cbe/databases/fars.shtml

Recently, individual access to the online version of FARS has also been made available by Wiley. The access is for periods of 6, 12, or 18 months. If packaged with a Wiley text the rates are $7.50, $15, and $20 for 1, 2, or 3 semesters. If purchased alone, those rates are $15, $30 and $40. (This information changes frequently, contact Wiley for most current arrangements.)

A recent article by the AICPA acknowledged concerns about the availability of databases for student research. The AICPA offers its own literature databases for a fee of $1,185 for the first year followed by $885/year thereafter. The AICPA Resource Literature can be accessed for $75/year by student members (student dues are an additional $30/year) or free by educator members. This database is similar to, but does not mirror exactly, the FARS used for the CPA Exam.

Students who have applied, and been deemed eligible, to take the CPA Exam can get a free six-month subscription to professional literature used on the Exam. However, the AICPA web site cautions:

The interface used by the online package is not exactly the same as that used in the operational CPA Examination. Candidates are strongly encouraged to also review the CPA Exam tutorial and sample tests found on this web site. The sample tests reflect the functionality and interfaces used in the actual examination.

Contents

This "system" contains six integrated databases (infobases):

1) Original Pronouncements - AICPA and FASB pronouncements, chronologically.
2) Original Pronouncements, as Amended.
3) Current Text- General Standards, Industry Standards and the Current Text sections that have been superseded but are still applicable due to a delayed effective date.
4) EITF Abstracts - full text and abstract for Emerging Issues Task Force.
5) Comprehensive Topical Index – combined topical index for Amended, Current Text and EITF infobases.
6) Derivatives Codification – implementation procedures for FAS # 133.

Use

Wallace's book [5] entitled "Mastery of the Financial Accounting Research System through Cases" is a comprehensive introduction to FARS. The author of this paper, after having attempted using the book, deemed the book too difficult for use with her students. A review of the book by Welsh [6] considers some of the examples "quite challenging" and suggests that the text be used across several courses or in a research seminar.

Ziebarts' book [7]takes students through the process of researching in accounting, concluding with simple research cases. (See Duffy et al. [1] for an example of how this book was used in Financial Accounting courses.)

Occasionally a case gets published that educators can use with their classes for exposure to FARS. One such case, actually a series of cases, by Forsyth and Dugan [2] exposes students to some seemingly inconsistent rules. Robson [4] appealed for new cases for classroom use. Alternatively, questions can be created by the instructor to be answered by using the FARS database. Excerpts of three such exercises, developed by the author of this paper to aid students in gaining familiarity with the FARS, are found in the Appendix.

CONCLUSION

Students majoring in accounting will be expected to use infobases to perform research if/when they sit for the CPA Exam and in real-world situations. Exposure to professional infobases as part of the undergraduate curriculum is desirable, yet few resources exist to aid professors in guiding students through the various resources. This paper provides an introduction to the FARS infobase by summarizing the current status of its use and accessibility. In addition it provides some "warm-up" exercises to help students become familiar with the contents of, and navigation through, the Financial Accounting Research System.

APPENDIX
FARS ASSIGNMENT 1 (Excerpts)
Introduction to FARS

Directions: You may cut and paste the answers from the Infobase when possible.
Please be sure your answer is complete but DO NOT include more text than necessary.

1. From the main screen of the FARS Database: list the seven selections available to you.

2. From the main screen of the FARS Database: Open original pronouncements: list the topics available to you.

3. From the original pronouncements of the FARS Database:
   a. Open the APB Opinions.
   b. Open APB Opinion 16. When was it issued?
   c. Find paragraphs 66 and 67. Para. 67 contains the definition of historic cost. After you read it, copy para. 67.

4. From the original pronouncements of the FARS Database: Open the "Statements of Financial Accounting Concepts."
   a. List the Concept Statements by name.
   b. Open Concepts Statement No. 2 and browse its contents.
   c. Choose two terms of interest to you from this statement and copy a sentence or two about each of the terms you chose. **Bold** the terms.

5. From the original pronouncements of the FARS Database: Open the "Statements of Financial Accounting Concepts."
   a. Open Concepts Statement No. 5 and do a search for "Comprehensive Income" (hint: use Search; Query).
   b. After reading it, copy the paragraph where you find the difference between Comprehensive Income and Earnings.

6. From the main screen of the FARS Database go to the topical index. Look up "conservatism" in this index. Which two concept statements cover conservatism? (State the numbers of the Concept Statements only).

FARS ASSIGNMENT 2 (Excerpts)
Introduction to FARS

1. From the main screen open the EITF Abstracts. Go to the introduction and find the answers to these questions:
   a. What does EITF stand for?
   b. Find a sentence stating who started the EITF, when, and why.
   c. What is required (how many) for a consensus of this task force?
   d. Why would it be important to have a consensus…what will this likely avoid?

2. In the EITF Abstracts, go to Income Statement Presentation: Discontinued Operations. Open EITF 95-18. (NOTE: 95-18 means the 18th abstract from 1995)

3. From the main screen open the Reference Guide…Overview:

    a. How would you have known that EITF 95-18 (or any pronouncement) had been superseded?
    b. What will superseded material be linked to?

4. From the main screen open the Topical Index and go to Income Statement Presentation: Extraordinary Items. Open EITF 01-10 (new route to where you were in question 2).

    a. What is its title?
    b. What are the issues? (read carefully, it seems to me the first 3 Para. under "Issues" are really background)
    c. How did they rule on Issue 1?
    d. Has this been superseded? How do you know?

5. From the EITF main screen:

    a. How are the Abstracts organized in the Topical Table of Contents?
    b. How are they organized under EITF Abstracts (full text)?
    c. Scroll and find a topic of interest to you. Copy its name and number.
    d. Scroll and find a topic that you don't understand. Copy its name and number.

FARS ASSIGNMENT 3 (Excerpts)
Searching in FARS

1. The Database lists three ways to search the FARS. What are they?

2. Access the Topical Index and click on C for Cash. Scroll down the "C's." How many columns of information do you see? What do they represent?

3. Locate "Cash, restricted". What references do you see? What is meant by "ARB43, ch3A, ¶6"? Cut and paste (and read) ARB43, ch3A, ¶6.

4. Go back to the original menu screen and open OP. Click on search on the menu bar. The last four choices are referred to as "query templates." What are the four choices available to you here? Why might this be a difficult way to search for information?

5. Answer the following:
    a. What symbol is used to perform a query?
    b. An advanced query?
    c. How else can you access the query and the advanced query?
    d. How do the query and advanced queries differ?

6. Answer the following:
   a. What type of "logic" is used to conduct an advanced query?
   b. How might you search for restricted cash here?
   c. What do you find when you try your search?

   RESEARCH APPLICATION: You are going to search for an answer to this question: ***"What is meant by 'market' in 'lower of cost or market' for inventory, and what are the constraints?"***

   6. What word might you search for in the topical index to answer the question? Give at least 3 alternatives.

   7. Search for the answer, using the topical index, and cut and paste the citation and the answer.

   8. Open the Original Pronouncements and do an advanced search for "lower of cost or market." How many hits do you get? Add: and "inventory". How many hits now? Go to the bottom of your screen and click on "Contents." What would you do next?

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AN EMPIRICAL STUDY OF THE IMPACT OF SARBANES-OXLEY ACT ON FORTUNE 500 COMPANIES: A PRELIMINARY REPORT

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Abstract

Since the Sarbanes Oxley Act (also known as SOX) was passed in 2002 many articles have been published in response to the impact the Act has made on many companies across the nation. The purpose of this paper is to find out how the Act has affected companies, specifically the Fortune 500 companies. A survey instrument was devised in order to find out the factors affecting the implementation of SOX and to identify existence of any obstacles in the implementation process. It is expected that results of this survey will shed some light on implications of this act on the companies that are implementing or are planning to implement SOX.

Introduction

The Sarbanes Oxley Act was signed by President Bush in 2002 after a number of companies faced accounting scandals. The Acts purpose is to, "protect investors by improving the accuracy and reliability of corporate disclosures made pursuant to the securities, and for other purposes (The Sarbanes-Oxley Act)." This act resulted in the fact that companies must abide by stricter rules for financial disclosure. "Sarbanes-Oxley keeps auditing firms from being both watchdog and advocate for their clients" (Carter, 2003).

Although some say that the full impact of the Act has not been felt, Sarbanes-Oxley has already made a major impact on the financial world and will continue to do so. SEC Chairman William H. Donaldson said, "The act represents the most important securities legislation since the original federal securities laws of the 1930s." This quote proves accurate when looking at the way it has already affected many major companies. This paper will focus on the problems the Fortune 500 of 2005 may have had while implementing the new regulations stated in the Sarbanes-Oxley Act.

Review of the literature

For this research we will search several journals such as ABA Journal, American Business Law Journal, CPA Journal, Harvard Law Review, Information Management Journal, Managerial Audit Journal, St. John's Law Review, Yale Law Journal. In addition, articles in journals that exist in electronic databases such as ABI/Inform and Business Source Premier will be searched to identify articles published that are related to SOX implementation.

Based on a cursory review of the literature, we have identified five important topics regarding the Sarbanes-Oxley Act. These topics include whistleblowers, management, attorney and client relationships, urge to privatize, and technological improvements in compliance with Sarbanes-Oxley.

The first issue discussed in many articles was the rights of the Whistleblower (typically an employee of a company who reports misconducts of their employer to someone of higher authority). Under the Sarbanes-Oxley Act the rights of Whistleblowers are protected by companies being required to establish anonymous hotlines for employees to report complaints (Kranacher, 2006). Before Sarbanes-Oxley, Whistleblowers were considered snitches and were faced with a very difficult decision on whether or not to report the unethical behavior of their employer. Since the passing of Sarbanes-Oxley, Whistleblowers face less of an emotional decision since the Act now protects them. "From a historical perspective, the whistleblower has evolved from snitch to corporate hero (Swartz, 2005)." Section 806 of the Act has "made it illegal to retaliate against an employee of a publicly traded company for providing information regarding securities fraud or violation of SEC rules to a federal regulatory or law enforcement agency, a member or committee of Congress, or a supervisor (Kranacher, 2006)." This provides Whistleblowers with a sense that no one in their company is allowed to turn against them, just because they have reported unethical behavior.

The second point identified was the increase in management responsibility. The responsibility of the CEO and CFO has been increased by requiring them to certify the accuracy of their financial statements (Gifford, 2004). Section 302 of the Act requires CEO's and CFO's to certify quarterly and annual filings with SEC (Koehn and DelVecchio, 2006). "The Sarbanes Act apparently goes further than the aforementioned cases by requiring managers to take affirmative responsibility for implementing and maintaining internal information systems (Fairfax, 2002)." This additional requirement puts more pressure on a manager because they will have to make sure the prepared financial statements are correct. This is crucial to a manager's job because if they pass by a large mistake, or notice it but fail to report it, it could result in the loss of their job and further penalties.

Since managers are now required to assess internal controls, the SEC has decided to help them with this process by providing guidance (Swartz, 2006). This guidance will assist them in its performance and also will be scalable and responsive to their individual circumstances (Swartz, 2006). The SEC announced that it was going to "issue a concept release and opportunity for public comment" (Swartz, 2006). In December of 2006, the SEC and did just that. This would allow public companies to discuss their views on the management assessment process so they can better understand the needs of all public companies. Also, the SEC wanted to help companies find a better approach to complying with Section 404 of the Act, so in December of 2006 they also released their proposal on new auditing standards (Swartz, 2006).

The third topic we found was the relationship between attorneys and their clients. SOX section 307 mandated that the SEC issue a rule to govern the conduct of attorneys representing public companies (Koehn and DelVecchio, 2006). The act requires that attorneys "report evidence of a material violation of securities law or breach of fiduciary duty or similar violation by the company or any agent thereof, to the chief legal consel or the chief executive officer of the company" (Tazian and Volz, 2006). This concerns attorneys because they do not feel as though they will be able to continue a confidential relationship with their clients. Also another issue is "individuals within the corporate client will hesitate to consult with the corporate attorneys on crucial matters for fear of being reported to management" (Tazian and Volz, 2006). This could cause problems in companies because employees will refrain from reporting unethical behavior to their attorneys. This could lead to more scandals and the downfall of companies. It is important that clients are confident with the relationship they have with their attorney so they will not feel as though they are talking to someone who will put them in a negative position within their company.

The fourth item identified was that many publicly held companies considered to privatize. When a company goes private its shares are no longer publicly traded. Also, private companies have the opportunity to pick and choose which parts of the Act they plan to implement (Schwartz and Stephens, 2006). Since Sarbanes Oxley compliance has made it more time consuming and expensive to run as a public company, many companies, especially smaller ones, may have the urge to go private. If a company were to go private it would avoid the costs of SOX compliance and the personal risk to their managers for failure to comply (Koehn and DelVecchio, 2006). Small companies may find it too much of a hassle to comply with SOX, so instead they are going private. For example, Collins Industries, a small company, has decided to go private since their SOX compliance would cost them approximately $1 million (Koehn and DelVecchio, 200). Also, in 2004 Foley & Landers conducted a survey of 115 public companies and found that twenty-one percent of these companies indicated they were considering going private due to Sarbanes Oxley (Schwartz and Stephens, 2006).

The last issue that we discovered was technological improvements in compliance with SOX. Many companies have found themselves spending hundreds of thousands of dollars to keep in compliance with the act (Koehn and DelVecchio, 2006). Different software has been developed in order to help companies comply with SOX. "Software assists in the documentation and testing of internal controls as well as adequately report compliance progress to executives," (Keohn and DelVecchio, 2006). General software has been developed as well as software to focus on specific sections of the Act. Specific software has been developed in to focus on Sections 404, 301, and also 409. Although a company could meet SOX requirements without investing in new software, having the correct software will help companies be more efficient in meeting the standards of SOX (Koehn and DelVecchio, 2006).

In addition to the above areas, we have identified one section of the Act that is discussed and reviewed in-depth by many experts. This is the section 404 of the Act. Although all sections of the Act are very important but Section 404 receives greater attention because

of its costly effects. Section 404 of the Act states "contain an assessment, as of the end of the most recent fiscal year of the issuer, of the effectiveness of the internal control structure and procedures of the issuer for financial reporting (The Sarbanes-Oxley Act)." Section 404 implies that top management in any publicly held company must take responsibility and maintain adequate internal control over the company's financial reports. This section has forced companies to spend millions of dollars and an extensive amount of time on their auditing systems.

Thhe rest of the paper is organized in the following way: Research Methodology, Findings and Discussion, and Conclusion and Implications.

Research Methodology

Our research is based on a battery of questions that will be sent to CFO and Controllers of the Fortune 500 Companies. The questionnaire contains several sections dealing with various issues related to the Sarbanes-Oxley Act. These answers to these questions will provide us with information on how companies have implemented the Act, and whether or not they have been successful, or have had problems.

Findings and Discussion

Since the results of the survey have not yet been received, we are unable to report any findings. Once the results of the survey have been received, they will be analyzed. By analyzing these results we will be able to find how successfully companies have been with implementing SOX. Also, we will find how the Fortune 500 companies have adjusted to the regulations of the Act.

However, based on our literature review we have identified several areas of concerns. They are: 1) the rights of the Whistleblower, 2) increase in management responsibility, 3) the relationship between attorneys and their clients, 4) publicly held companies considering going private, 5) technological improvements, and 6) Section 404.

Conclusion and Implications

At this time no conclusions have been made due to the fact the results of the survey have not been received. Once the results have been received they will be analyzed to find how the implementation of SOX has affected Fortune 500 companies.

References are available upon request from the second author.

CHANGES IN ATTITUDES TOWARDS BUSINESS ETHICS OF FUTURE MANAGERS IN THE UNITED STATES

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ABSTRACT

This paper reports results from the use of the Attitudes Towards Business Ethics Questionnaire (ATBEQ) in 2004 and compares these results with those attained by Preble and Reichel in 1987. Significant differences between U.S. business students in 1987 and U.S. business students in 2004 were seen on twenty-two of the thirty items that measure ethical business attitude. The cumulative impact suggests a significant overall attitudinal change, where the 2004 data indicate a movement towards more moderate or neutral attitudes. The results suggest that business schools consider review and assessment of the ethics component of their programs.

INTRODUCTION

In recent years, the news has been filled with reports of unethical business behavior from respected companies such as Enron, WorldCom, Tyco and Hewlett-Packard. The number of improprieties appears to be on the increase and this has seemingly resulted in a plethora of studies on the topic of business ethics. Educational institutions are not exempt from these ethical problems and evidence of academic dishonesty abounds. A survey of graduate students in the United States and Canada found that 56 percent of graduate business students admitted to cheating in the past year compared with 47 percent of non-business students. Students commented that it was an accepted business practice and one they'll need to succeed in their professional lives (McCabe, 2006). This does not fare well for ethical behavior in the managers of the future.

LITERATURE REVIEW

The increasingly global economy necessitates a study of ethical attitudes both within and across cultures. A 1988 article written by Preble and Reichel reported the results of using the Attitudes Towards Business Ethics Questionnaire (ATBEQ) to compare the attitudes of American and Israeli management students. Statistically significant differences were found between the two groups on nineteen of the thirty statements. In many instances, the authors claimed that, although the differences were significant, they were not necessarily meaningful. The authors found that both groups "held relatively high moral standards" (Preble and Reichel, 1988, p. 941). The U.S. students disagreed (2.4) that "business decisions involve a realistic economic attitude and not a moral philosophy" while the Israeli students expressed mild agreement (3.6). U.S. students also disagreed (1.8) that "business ethics is a concept for public relations only" while the Israeli students expressed neutrality (2.8).

Small (1992) continued the study of student attitudes toward business ethics by comparing data collected from Curtin University students in Western Australia to data collected by Preble and Reichel for both U.S. and Israeli students. The attitudes of the U.S. and Australian-based students were similar although ten statistically significant differences were noted. The attitudes of the Israeli students appeared less similar to those of the Australian students with nineteen significant differences noted. Small concurred with the comment by Preble and Reichel declaring that the differences found were not particularly meaningful. There were no instances where one national group expressed strong agreement with a specific statement while a second group expressed strong disagreement with the same statement.

In 1999, Lin published a study using ATBEQ to compare attitudes of Taiwanese students to those of students from the U.S. and Israel (Preble and Reichel, 1988), and Australia (Small, 1992). Lin noted that the Chinese students had more moderate attitudes and attributed it to cultural differences whereby the Chinese rarely express strong agreement or disagreement (Lin, 1999, p. 644). To correct for this cultural difference, Lin added a ranking component using values of the mean response to each statement in order to explain the perceived degree of agreement or disagreement. The lowest mean was given a rank of one (1) out of thirty and the highest mean was a given a rank of thirty (30). Students showed the greatest disagreement with the item ranked number one and the highest level of agreement with the statement ranked number thirty. Lin compared the rankings by calculating, for each item, the differences in ranks between groups. Lin suggested that the ranking component be added to aid in the interpretation of comparative data. The overall research findings reported by Lin indicate "a pragmatic, result-focused, and profit-oriented younger generation in Taiwan" (Lin, 1999, p. 652).

Moore and Radloff extended the study of ABTEQ and student attitudes to South Africa. In their study, the determination of significant differences between groups (U.S., Israel, Australia, and South Africa) was based on finding significant differences on at least 50% of the statements. On this basis, only the Israeli students were found to differ significantly from the South African students. The authors suggest that all results be viewed holistically. The cumulative effect of the differences should be viewed as meaningful rather than merely viewing one question at a time. Thus, finding 50% of the statements to elicit significant differences should be viewed as a finding of differences in ethical business attitudes between national samples (Moore and Radloff, 1996, p. 868). Using their basis for determining significant attitudinal differences, significant differences would be reported between 1) U.S. and Israeli students, 2) Israeli and Australian students, 3) Taiwanese and U.S. students, 4) Taiwanese and Israeli students, and 5) Taiwanese and Australian students.

Sims and Gegez (2004) provide a five nation comparative study involving the United States, Israel, Western Australia, South Africa and Turkey. They report differences between the graduate business students in Turkey and students from all other countries. Significant differences in attitudes were reported on fourteen (14), fifteen (15), fifteen (15) and sixteen (16) items respectively for the comparisons with U.S., Israel, Western Australia and South Africa.

All of the studies described above contribute to an increase in understanding of cultural differences with respect to attitudes towards business ethics. In the increasingly global economy,

it is imperative that organizations discuss differences in attitudes and find ways to reduce conflict with respect to ethical decision-making. Although a respect for diversity must be fostered, a collective agreement on professional standards is necessary to reduce or eliminate ethical conflict resulting from diverse cultures and differing perceptions of right and wrong (Ferrell, 1999, p. 226).

Business schools are taking an increased interest in ethics education. The fall 2004 issue of BGS International Exchange explored business ethics in response to the business scandals of 2001 and 2002 and the fall 2006 issue announced an organizational focus on "Ethical Business Leadership." John Wholihan, President of Beta Gamma Sigma, the honor society serving business programs accredited by AACSB International, wrote that the Board plans "to develop ways to encourage business leaders to adhere to the highest ethical standards, and to show that this is one of the most important aspects of leadership in the 21st century" (Wholihan, 2006, p. 2).

AACSB International, the Association to Advance Collegiate Schools of Business, the premier business school accrediting agency, now hosts an Ethics Education Resource Center on its website. In June 2004, the Ethics Education Task Force established by AACSB published a report on "Ethics Education in Business Schools." In the foreword, Susan Philips wrote that "the crisis in business ethics is not only a challenge for companies but also an opportunity to strengthen management education" (Report of the Ethics Education Task Force, 2004, p. 7). AACSB firmly supports ethics education as an integral part of any business curriculum. Their report states that business schools must "renew and revitalize their commitment to the centrality of ethical responsibility at both the individual and corporate levels in preparing business leaders for the twenty-first century" (Report of the Ethics Education Task Force, 2004, p. 9).

This research will compare and contrast the attitudes of U.S. business students in 1987 with those seen in 2004 using ATBEQ. We hypothesize that there has been a change in attitudes as measured using the holistic standards applied by Moore and Radloff. If significant differences are found on 50 percent or more of the items, we will conclude that there has been a change in attitudes of U.S. business undergraduate students during the seventeen year time span from 1987 to 2004.

METHODOLOGY

The Attitudes Towards Business Ethics Questionnaire (ATBEQ) was used to compare the attitudes of U.S. undergraduate business students in 1987 with the attitudes of U.S. undergraduate business students in 2004. This questionnaire consists of thirty statements that are "related to various business philosophies like Social Darwinism, Machiavellianism, Objectivism, and Ethical Relativism" (Preble and Reichel, 1988, p. 943). Student responses are measured on an ordinal scale that varies from strongly disagree (1), to disagree (2), to neutral (3), to agree (4), to strongly agree (5).

The 1987 study, conducted by Preble and Richard, included 129 undergraduate management students from a Middle-Atlantic U.S. university. Forty-five percent of the students were male

and fifty-five percent were female. They ranged in age from 20 to 37, with 85 percent being 21 to 22 (Preble and Richard, 1988, p. 943).

The 2004 study included 214 undergraduate business students from six colleges in the northeast region of the United States. Seventy-one percent of the students were enrolled in private institutions with twenty-nine percent enrolled in public colleges. Students from schools with (thirty-two percent) and without (sixty-eight percent) religious affiliation were surveyed. The representation of male and female students was fifty-six and forty-four percent respectively. Freshmen, sophomores, juniors and seniors comprised twenty-four (24), twenty-three (23), thirty-one (31) and twenty-two (22) percent of the respondents respectively. Students ranged in age from 17 to 50 with ninety-eight percent in the 17-23 years old age category. Forty-two percent of the respondents reported that they had taken no courses in ethics or religious studies. Twenty, seventeen, fourteen and five percent reported taking one, two, three or four courses in ethics and/or religious studies. Whereas fifty-nine percent of the students from schools without a religious affiliation reported zero ethics and/or religious studies courses, seventy-six percent of students from schools with a religious affiliation reported taking two or more ethics and/or religious studies courses.

RESULTS

Using the methodology of Moore and Radloff, which looks at cumulative impact, rather than individual *t*-tests, provides evidence of significant difference between the attitudes of U.S. business students in 2004 and 1987. There are statistically significant differences on twenty-two of the thirty comparisons. In almost all cases, the 2004 results indicate a movement toward neutrality and away from stronger agreement or disagreement with the attitudinal statements. On statement 1, for example, "the only moral of business is making money," the 1987 data indicate disagreement while the 2004 data show neutrality. Although the 2004 data for statement 2, "a person who is doing well in business does not have to worry about moral problems" indicate disagreement (1.93), that disagreement is less extreme than reported in 1987 (1.6). Less disagreement and a movement towards neutrality is also reported on statements 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 20, 21, 22, 27, and 28. For statements 18 and 26, there is a move away from greater agreement and, once again, towards neutrality. The data for statement 3, "every business person acts according to moral principles, whether he/she is aware of it or not" indicate more disagreement in 2004 (2.57 versus 2.9). There is greater agreement evidenced in 2004 for statement 13, "as a consumer when making a car insurance claim, I try to get as much as possible regardless of the extent of the damage" (3.31 versus 3.0). Finally, the data for statement 30, "you should not consume more than you produce," indicate greater agreement although the 2004 mean is closer to neutral.

In 2004, the mean data indicate the greatest agreement with statement 23 (if you want a specific goal, you have to take the necessary means to achieve it), statement 18 (the main interest of shareholders is maximum return on their investment) and statement 29 (you can judge a person according to his work and his dedication). This is quite similar to the data collected in 1987 where these three statements rank as numbers two, one and four with respect to agreement. With respect to disagreement, once again there is great similarity. The statement with the lowest mean

in 2004, indicating the greatest disagreement, is statement 14 (while shopping at the supermarket, it is appropriate to switch price tags on packages). The mean value for statement 2 (a person who is doing well in business does not have to worry about moral problems) is next lowest followed by statement 7 (moral values are irrelevant to the business world). In 1987, these statements are ranked two, three and one with respect to disagreement.

An examination of rank order combined with an examination of means indicates that, although students tend to have the strongest agreements or disagreements with the same attitudinal statements, the strength of their beliefs is somewhat diminished. For most statements, the means have moved towards neutrality or perhaps towards a meaning of "not sure."

Lin's methodology considers the range of mean values, "the difference between the highest and lowest item mean" (Lin, 1999, p. 644). The ranges of mean values reported in the literature were 2.6, 2.5, 2.67, 1.88, and 2.34 for the U.S., Israeli, Australian, Taiwanese and South African groups. Lin stated that the smaller range seen in the Taiwanese was likely due to a disinclination by the Chinese people to express strong agreement or disagreement due to emotional restraint (Lin, 1999, p. 644). Although this characterization may be true, the range of mean values for the 2004 U.S sample is 1.74, the smallest range. As noted earlier, the U.S. students seem to have moved away from more positive or negative agreement and moved towards neutrality on the attitudinal items. One would have to consider the possibility that this change in attitudes from 1987 until 2004 was fostered by the movement towards "political correctness" where no one want to offend any group and thus few strong emotions and attitudes are openly expressed.

Lin suggested that, to facilitate comparisons, particularly comparisons across cultures, the ranking differences should be examined. The ranking differences were calculated by taking the absolute value of the difference in rank between groups for each statement. Only items with 1) differences in means as measured by significant *t* scores and 2) a ranking difference over 5 were included in a discussion of noteworthy findings. Using the Lin methodology, true differences were seen only in items 1, 13, 20, and 26. As stated earlier, on item 1, "the only moral of business is making money," the 1987 data indicate disagreement (1.9) while the 2004 data show neutrality (2.64). The ranking (from lowest mean to highest mean or from greatest disagreement to greatest agreement) was 5 in 1987 and 11 in 2004, a ranking difference of 6.

Statement 13, "every business person acts according to moral principles, whether he/she is aware of it or not," had a 10 unit change in rank. In 1987, students were "not sure" or expressed neutrality with a mean score of 2.9. In 2004, the mean score was 2.57 and thus the students evidenced some mild disagreement with the attitude. It appears that the recent improprieties by major corporations may have changed student attitudes towards the morality of the actions of business people.

Item 20 reads, "for every decision in business the only question I ask is, "will it be profitable?" If yes - I will act accordingly; if not, it is irrelevant and a waste of time." In 1987, students expressed disagreement with this attitude (2.0), while in 2004, students were neutral (2.8). One might ask if profitability trumps morality and ethical behavior as long as the decision leads to increased profit. The results for item 20 appear to correspond with the results seen in item 1.

Finally, statement 26, "I would rather have truth and personal responsibility than unconditional love and belongingness" had a seven unit change in rank (21 in 2004 and 28 in 1987). In 1987, the students mean was 3.4 (at least mild agreement) whereas in 2004, the student mean provided evidence of overall neutrality (3.03). It should be noted that Moore and Radloff recommended the removal of item 26 from the questionnaire because it had not measured significant differences in any earlier studies.

CONCLUSION

Significant differences between U.S. business students in 1987 and U.S. business students in 2004 were seen on twenty-two of the thirty items that measure ethical business attitudes using ATBEQ. Using the holistic methodology advocated by Moore and Radloff, since there were differences on more than fifty percent of the statements, the cumulative impact suggests a significant overall attitudinal change.

The differences seen evidenced a movement towards neutrality (3.0 on the 5-point scale) and away from expressing strong agreement or strong disagreement with the attitudinal statements. Differences greater than a rank change of more than five units were seen in only five statements and one of these did not have a significant change in the mean score. Using the methodology of Lin which incorporated findings of significant mean differences with ranking differences greater than five, only four items were found to be noteworthy.

Clearly, the results indicate a considerable change in U.S. business student attitudes during the period from 1987 to 2004. The 1987 and 2004 data were collected from students at a Middle-Atlantic university and students in the northeast respectively. If there were any differences resulting from location, one would hypothesize that students in the "liberal" northeast would be more likely to express extreme views and show greater agreement or disagreement with the thirty attitudinal statements. Instead, the 2004 data indicate a movement towards more moderate or neutral attitudes. The range of means has narrowed and it appears that students are less likely to express strong views.

Although business schools have begun to pay more attention to ethics education in their curricula in hopes of developing ethical business professionals, the 2004 U.S. survey results, as compared with the 1987 U.S. results, indicate that there is much work to be done. Business schools must review and assess the ethics component of their programs.

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The questionnaire and references are available from Susan E. Pariseau upon request.

ETHICAL JUDGMENT OF IT PROFESSIONALS: EFFECTS OF INDIVIDUAL, OCCUPATIONAL, AND WORK STRUCTURE CHARACTERISTICS

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ABSTRACT

IT ethical and security violations make the news often and regularly. Although many IT professionals use good ethical judgment, those who do not can cause significant financial impact as well as reputational damage to the IT profession. Previous studies of ethical judgment have not focused upon IT professionals who differ from the general workforce because they may have more opportunity and sophisticated skills to abuse IT ethical and security guidelines.

Key Words: Ethical Judgment, IT Professionals, Professional Ethics, IT Security

SUMMARY

A new question in the 2006 CSI/FBI Computer Crime and Security Survey [7] asked respondents to estimate what percentage of cyber losses was attributable to insiders. A large number of survey respondents felt that insiders contribute significantly to overall cyber losses in an organization. Respondents included employee misuse (12%), leakage of private information (intellectual property and business secrets) (52%), and internal network security – insider threat (38%) as some of the most critical data security issues for the next two years, despite increased spending in and emphasis upon technical data security measures, data security awareness training, and enhanced data security organization structures [7]. Often, the employees with the requisite technical skills to create data security problems are among the ranks of IT professionals. It is the IT professional (vs. other professionals) who has more of a tendency to "hack" [15] so that is why it is important to concentrate on ethical judgment among IT professionals.

Overall, the current state of ethics within the IT community makes headlines at least once a week. Many, if not most, IT professionals are ethical and hard-working. However, the unethical IT professional can do large amounts of damage that will generate big news. For example, the international group of virus creators who call themselves "29A" post virus software scripts on the Internet but do not use the scripts themselves. They let "script kiddies" use the virus scripts to release the viruses. This group admits to creating the viruses because the code for viruses is a software challenge and it stretches their technical creativity. However, they do not feel that they are acting unethically because they don't actually release the virus/worm/Spam, though they have made it available for others to do so [3] [10]. Some virus writers are hired to work for anti-virus or security software companies and create viruses as part of their job to learn how to

protect against different types of viruses. These 'white hat' virus writers always need to use good ethical judgment so that they do not misuse these 'test' viruses passively or actively.

In another situation, Donald Gene Burleson, a systems analyst for an insurance agent/broker, set up a logic bomb in his employer's computer. When he was terminated, his bomb program was triggered when it detected that his name was missing in the payroll files. The bomb deleted over 150,000 sales commission records from the employer's data files [5] [8]. There are actually a number of variations on this type of security lapse. Some employees use a time code or password that must be renewed by a certain date/time or there are various repercussions: executable code is deleted, a virus is released, or files are deleted.

Software Quality is yet another critical area of ethics in IT. IT professionals have a responsibility to write the best systems they can, with the fewest errors and problems as possible and to test it to the best of their ability [9] [11] [17]. Microsoft and other software developers admit to having bugs in Windows and are committed to working on their software to eliminate the security errors, fix the bugs, and try to stop any additional security holes. It is critical for employees of commercial software developers to demonstrate high levels of ethical judgment when working under tight deadlines and other constraints so that they do not add 'back doors' or fail to notice vulnerabilities in the code.

Due to publicity such as the CSI/FBI survey and daily 'hacker' headlines, more companies are creating standards, undergoing security software audits, raising awareness, and improving overall security, but there are still holes in the effort. In the CSI/FBI study [7], respondents from most sectors felt that increased data security awareness training was warranted. In smaller companies, who generally do not have a full time network administrator, it has not been uncommon to commit one or more security gaffes: to neglect to delete passwords/network access privileges of former employees, to fail to change the network system or administrator passwords, and to have little or no security procedures documented and in place. Since 9/11, many companies now see the value of these procedures, and have worked to set new auditing procedures, as well as periodic security audits, in place [19].

Understanding ethical judgment (and its antecedents) among IT professionals is an important first step in tailoring and timing security awareness training, planning and conducting security audits, and proposing an overall code of ethics for IT professionals. However, there has been limited research of ethics among IT professionals [2] [4] [12] [13] [14] [15]. In previous studies among IT professionals, the dependent variable, ethical attitude/behavior, builds upon the well-researched area of Theory of Reasoned Action/Theory of Planned Behavior [1] [6]. In our conceptual study, we propose a model based upon the research areas of IT professionals and ethical judgment. Our model will enable us to study the effect of several antecedents, including personal characteristics, work experience, work structure, and job satisfaction, upon the construct, ethical judgment. We are interested in evaluating how certain characteristics might impact an IT professional's ethical judgment across various typical dilemmas or scenarios faced by an IT professional. The dependent variable, ethical judgment, can be operationalized by capturing respondents' reactions to various ethical vignettes [18].

Other professions, such as public accounting, have developed ethical standards that guide and nurture the ethical behavior of their members. If the IT profession is to achieve comparable professional status, the ACM, ICCP, DPMA, and/or IEEE need to agree on a common Code of Ethics and an oversight board that will work for IT as a profession [16].

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SARA LEE CORPORATION: THE REFRIGERATED PROCESSED MEATS SEGMENT OF THE MEAT PRODUCTS INDUSTRY

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ABSTRACT

On February 10, 2005, Sara Lee Corporation, a global manufacturer and marketer of high-quality, brand name products for consumers throughout the world, announced a comprehensive plan to transform the entire enterprise into a tightly focused food, beverage, and household products company. The main problem to be resolved for Sara Lee Corporation was how to differentiate itself from other big players such as Kraft Foods, Tyson Foods, Smithfield's Foods, and Oscar Mayer and so achieve a winning edge over these competitors within intensively competitive, rapidly changing immediate, intermediate, and long-term time frames.

OVERVIEW OF THE INDUSTRY AND ITS STRUCTURE

The refrigerated processed meat segment was a sub-segment of the meat industry. Products in this segment included breakfast meats, luncheon meats, frankfurters/sausages, and other refrigerated meat products. This segment presented a two-tiered competition landscape: meat processors (Tyson Foods and Smithfield's Foods) and meat marketers (Con Agra and Kraft Foods).

Products

The products in the refrigerated processed meat industry were breakfast meats, luncheon meats, frankfurters/sausage, and other refrigerated meat products. Each product had a variety of brands and product lines as it essentially covered a different type of refrigerated processed meat market.

Operations

Once the product line was established, processing and marketing became the areas of focus. Many of the major players in the meat industry processed the meat and also marketed them using their own brands and products lines as it created cost efficiency. However, some companies outsourced the processing and only marketed the meat products using their own brands.

Consumers

Consumers of refrigerated processed meat were motivated by their taste preferences and desire to maintain a healthy lifestyle. The consumers of refrigerated processed meats were from a wide audience with varying ages and number of the members of a household, ethnicity, income, level of education, and gender.

Advertising/Promotions

The refrigerated processed meat market had seen widespread branding and marketing initiatives undertaken by the top marketers. In addition to marketers, industry associations, such as the National Cattleman's Beef Association and the National Pork Board ran their own consumer campaigns on the safety and benefits of beef and pork respectively. The advertising and promotions initiatives used by players in refrigerated processed meat industry included brand consolidation, endorsements, and consumer promotions.

Regulatory
Like many industries, the meat industry was regulated by various bodies. All meat products were subject to strict monitoring by the Food and Drug Administration (FDA) and the United Stated Department of Agriculture (USDA).

Outlets
Distribution outlets were important in this industry as it was the avenue for the products to get to the consumers. Distribution channels included chain outlet stores, deli services, and online stores.

Industry Opportunities and Threats
The industry's opportunities included new product lines, renewing and reinforcing core brands, online stores that provided customized services, and developing and new markets. Threats included increased competition from other players in the industry, an increase in prices as a result of increasing operating costs, short-term and fading, and consumer trends.

COMPETITION

The refrigerated meat market presented a two-tiered competition landscape: meat processors (Tyson Foods, and Smithfield) and Marketers (Con Agra, and Kraft Foods). Meat processors had the advantage in terms of pricing meat products. This was evident in the sales decline of Sara Lee's products such as hot dogs and breakfast sausage, which struggled with high selling prices at retail. Meat packers were forced to concentrate more on innovate and value-added products such as ultra-thin luncheon meat, after which the sales of these meat packers had been on the rise.

Tyson Foods
Tyson Foods, Inc., founded in 1935 by John Tyson, with headquarters in Springdale, Arkansas, was the world's largest processor and marketer of chicken, beef, and pork. Tyson became the world's largest poultry producer by merging with its competitor Hudson Foods and in 2001, the company doubled in size by acquiring its rival, IBP. Tyson's core business was chicken and poultry products until it acquired IBP, a leading fresh beef producer. The company operated in four business segments: Chicken, Beef, Pork, and Prepared Foods. In 2003, Tyson foods faced a major challenge in communicating its new position as a major meat marketer from a focused chicken processor. The company spent $100 million in advertising and promotional initiatives to communicate the integration of IBP's brands into its fold and to emphasize that Tyson brand stood for more than just chicken. In August 2004, Tyson launched a new positioning as the world's leading provider of protein with the tag line, "Powered by Tyson." The campaign, based

on extensive consumer research, pointed to the importance of meat in the diet as a source of protein while highlighting Tyson's chicken, beef, and pork products. In September 2004, Tyson teamed up with Viacom's CBS in a product placement deal. Tyson products were integrated into the third season episode of CBS's Monday night situation comedy "Still Standing."

The major strength of Tyson was in its branding quality reputation and strategy which focused on Tyson as the national brand for chicken, beef, pork, and prepared foods. Tyson also produced private label products for customers under a two-tier strategy in which both branded and private label products were provided for better overall growth. Tyson brands were competitively priced and widely recognized. Also, the standards set by the regulatory bodies such as the FDA were followed and the quality of its refrigerated processed meat products was maintained by delivering products to destinations on time and ensuring freshness as a result of this. Tyson was an innovative player in the meat industry as it provided convenient products, business builders, and menu ideas for its customers. In terms of outlets, Tyson maintained good relationships with its distribution networks and also provided competitively priced products. Although Tyson's products were widely recognized and purchased, the companies weakness was its inability to monitor understand the skipping market trends and develop products that represented that changing markets. Tyson foods also had little online presence and the company was yet to implement online stores where consumers could order and customize their product of choice.

Smithfield Foods, Inc.

Smithfield Foods, Inc. founded in 1936, had expanded through acquisitions: Valleydale Foods in1993; John Morrell in 1995; Lykes Meat Group in 1996; Murphy Family Farms in 2000; Vall Hog Production Company in 2002; Cumberland Gap Provision Co., and Farmland Food in 2003. Smithfield Food's line included pork, beef, and other meats. The company had vertically integrated into hog production through its Hog Production group, which provided the processing group its live hog requirements. Its major brand lines included Gwaltney, John Morrell, Lykes, Jamestown, Cumberland Gap, and Farmland Foods. In 2004, Smithfield announced the Bacon Strategy to improve margins on fresh bellies and increase market share in the bacon segment. The company was also the market leader for the declining non-sliced lunchmeat segment.

Smithfield's major strength was that it used customized promotions to limit costs and maximize results. The company's chain-tailored or regionally specific programs included cross-promotions with other items, sweepstakes, sampling, and targeted radio and print advertising. Smithfield brands were competitively priced and widely recognized. Also, the standards set by the regulatory bodies such as the FDA were followed and the quality of its refrigerated processed meat products was maintained by delivering products to destinations on time and ensuring freshness as a result of this. In terms of outlets, Smithfield's maintained good relationships with its distribution networks and also provided competitively priced products. Smithfield's weakness was its relatively higher product prices. Its product lines featured a diverse variety of products ranging from breakfast meats to specialty meats that were priced slightly higher than that of other competitors. Also the convenience packaging was an industry trend that many of the big players in the industry had adopted but Smithfield's product packaging had remained the same. Smithfield's foods also had little online presence and they were yet to implement online stores where consumers could order and customize their product of choice.

Kraft Foods

Kraft Foods, majority owned by Altria Group (formerly Philip Morris), was U.S.'s largest and the world's second-largest food company, with net revenues of over $31 billion in 2003. Snacks, beverages, cheese, grocery, and convenient meals were the company's core business sectors. Oscar Mayer was the leading brand in refrigerated bacons, frankfurters, and sliced lunchmeat. The strengths were in its acquisition growth strategy and innovation development which enabled it to deliver volume growth. Kraft continually introduced products across the food industry's key categories taking into account industry and consumer trends such as convenient meals and snacks, or health and wellness concerns. Kraft's refrigerated meat product included Oscar Mayer and Louis Rich. Oscar Mayer's products included hot dogs, Louis Rich cold cuts, Lunchables lunch combos, and bacon. Kraft's brands were competitively priced and widely recognized. Also, the standards set by the regulatory bodies such as the FDA were followed and the quality of its refrigerated processed meat products was maintained by delivering products to destinations on time and ensuring freshness as a result of this. In terms of outlets, Kraft Foods maintained good relationships with its distribution networks and also provided competitively priced products. Kraft Foods weaknesses were in the company's ability to introduce new products that fit the changing consumer tastes and preferences hence its products were not flexible. Kraft Foods also had little online presence.

CON AGRA

ConAgra, another top U.S. food producer, was the largest foodservice supplier offering shelf stable, packaged, refrigerated, and frozen foods. The company's sales for the fiscal year ended May 2004 was $14.52 million, a decline of 27% over the previous year, mainly due to the selling off of its non-core activities. ConAgra, with 2003 mass-market sales of $828.45 million, was the third largest player in the refrigerated processed meat market, behind Kraft Foods and Sara Lee. The company's products included hot dogs, bacon, ham, sausages, cold cuts, turkey products, ethnic foods, and kosher products. The company offered these products under the Armour, Butterball, Hebrew National, Healthy Choice, and Eckrich brands. ConAgra was in a restructuring mode in keeping with its strategy to focus on its core branded and value-added food business. With the divestures of its non-core businesses, ConAgra was targeting a core business with better focus and marketing support.

Con Agra brands were not competitively priced but they were widely recognized. Also, the standards set by the regulatory bodies such as the FDA were followed and the quality of its refrigerated processed meat products was maintained by delivering products to destinations on time and ensuring freshness as a result of this. In terms of outlets, Con Agra maintained good relationships with its distribution networks and also provided competitively priced products. Although Con Agra's products were widely recognized and purchased, the companies weakness was its inability to monitor understand the skipping market trends and develop products that represented that changing markets. Con Agra's weakness was also its relatively higher product prices. Con Agra also had little online presence.

THE COMPANY

Sara Lee was a global manufacturer and marketer of brand-name products for consumers. Since its inception in 1939, Sara Lee has grown to a leading company in consumer packaged goods, operating in 58 countries and marketed in nearly 200 nations.

Products
Sara Lee's products were manufactured a variety of consumer products under three main divisions which were Branded Apparel, Household and Body care, and Food and Beverage. Sara Lee Food & Beverage developed and sold many of the world's favorite high-quality baked goods, meats and coffee. Leading brands and products included Sara Lee fresh breads, frozen desserts and deli meats, Hillshire Farm lunchmeats, Jimmy Dean sausage and breakfast foods, and Ball Park franks. Regarding its products, Sara Lee was strong and on par with other competitors, except in monitoring and understanding skipping market trends and in its new and innovative product capability in which it was a weak competitor.

Operations
Sara Lee manufactured its products in a variety of facilities which were either company-owned or outsourced. The company owned several facilities its divisions across the country and in international locations. Sara lee outsourced from manufacturers/suppliers for many years and developed strategic alliances with many of them over the years. Regarding operations, Sara Lee was strong in control over its operations, good employee relation, and communicating between sourcing and outsourcing partners. However, the company was weak in maintaining cost effectiveness in its company-owned facilities.

Consumers
Sara Lee products ranged from all ages, genders, and income levels because of the wide variety products offered by the company. The food and beverage division of Sara Lee marketed to a general range of consumers of various ages, genders and income levels. The company was strong in all keys to success regarding consumers, except for manufacturing and marketing new and innovative products that blended a wide range of consumer preferences together.

Advertising/Promotions
In order for major players to stay ahead in the branded apparel, food and beverage, and household and care products industry, Sara Lee used advertisements and promotions as a major part of its strategy. The company embarked on a campaign to spend heavily on advertising, marketing, and marketing research in order to stay ahead of the curve. Sara Lee advertising/promotions strategy included using endorsements, consumer promotions, television, radio, and the Internet. In regards to advertising, Sara Lee was strong in all keys to success except for its ability to leverage on brand recognition and loyalty by consolidating smaller brands to top ones, in which it was behind competition.

Distribution Outlets
Sara Lee sold its products through the wholesale and retail outlets. These outlets included chain stores and independent deli stores. Sara Lee maintained good relationships with its distribution networks by providing competitively priced products, it failed to leverage its new, highly skilled, national account sales team to better understand customer needs based on distribution channels

and develop innovative solutions to meet these needs. In terms of the online distribution channel, Sara Lee products were not widely distributed using online stores.

Management of Sara Lee needed to differentiate TFK from the competition and so achieve a winning edge over competitors within an intensely competitive and rapidly changing industry.

THE PAN-MASSACHUSETTS CHALLENGE

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ABSTRACT

This case involves an introduction to forecasting using trend lines and simple linear regression in Excel. The objective of the forecasting exercise is to generate projections of the number of participants and the total amount of contributions in an annual philanthropic athletic event. The students receive reinforcement regarding the integration of mathematics with the other functional components of management and the responsibilities of business people to the greater community.

INTRODUCTION

The primary objective of this case study is to provide first year students in a business undergraduate curriculum with an early-on experience in the analysis of real data. There are a number of secondary objectives that bridge the areas and ideals of integrated education, health and fitness, and the role of individuals and businesses in giving back to the community at large.

Special attention is given to the role of the first course, Quantitative Methods with Calculus, the integration of our introductory mathematics with the other functional components of the curriculum, and the responsibilities of us all to the greater community.

QUANTITATIVE METHODS WITH CALCULUS

This fall semester course is typical of many introductory math experiences for first year students. While the faculty cannot wait to plunge into the deltas and epsilons of calculus, there is the mandatory review of basic algebra, such as fitting a line when the coordinates of two points are known. Our current textbook [1] includes a section at the end of Chapter One that addresses the fundamental question of what does a manager do if there are more than two points through which to position a line.

A little bit of simple regression at this point in the students' education does not hurt very much. In fact, it can open their eyes to new ways of thinking.

FIRST-YEAR MANAGEMENT EXPERIENCE (FME)

The First-year Management Experience (FME)has become a legend in our institution. The "experience" is a melding of the tired old courses entitled "Introduction to Management" and "Introduction to Information Systems."

The students are locked together for two six-credit courses, fall and spring of their first year. The major assignment for their spring semester is to set up and manage a for-profit business. The 400 to 450 first-year students are assigned into roughly 14 teams or "businesses" of size 30 each. They learn a lot about interpersonal relationships within their organizations, as well as the numbers on their profit and loss statements.

Each business must select a charitable organization to which all of their profits will be granted. In addition, each team must spend a substantial number of hours in charitable work for worthy projects and organizations, such as assistance in shelters for homeless citizens in the nearby city of Boston or volunteering to coach men and women in local senior centers in the development of their computer skills.

We, as faculty and staff, sincerely strive to impress upon our students the need to respect and help the greater community.

THE CASE

The draft form below of the Pan Massachusetts Challenge case is abbreviated due to copywrite and confidentiality purposes:

Pan-Massachusetts Challenge

Early in the morning on Saturday, August 9, 1980, thirty-six hearty young men and women mounted their bicycles in Sturbridge, Massachusetts, to set off on a trek towards Provincetown, the very funky end-of-the-road village at the tip of Cape Cod. This planned 192 mile excursion over a two-day period certainly provided these folks with the elevated charge associated with the anticipation of such an adventurous challenge. However, the official objective of this athletic event of marathon proportions was to raise money, via pledges of donations from family and friends, for the support of scientific research for the treatment and prevention of cancer.

The monetary rewards for their labor deserved a warm round of applause. The receipts from the generous supporters resulted in a contribution to the Jimmy Fund of $10,200. None of the participants of this 1980 summertime bike ride, especially the organizer, Billy Starr, could imagine what would follow in the next quarter century.

Billy Starr

Billy Starr was raised in the comfortable environs of Newton, Massachusetts, an affluent suburb of Boston. In his own words, "I was a good athlete, okay enough student and had proficient enough social graces as to get by." He was very much involved in outdoor activities, and elected to do his college education in Colorado, where he could actively participate in hiking, skiing, and biking. Very shortly after receiving his undergraduate degree, as he was about to embark upon an ambitious hiking expedition in Nepal, he received word that his mother had been diagnosed with cancer.

Betty Starr died at age 49. Billy Starr was 25 at the time of his mother's death.

Billy Starr nurtured the Pan-Massachusetts Challenge (PMC)from a $10 thousand fund raising activity in 1980 to the nearly $25 million per year event that it has become a quarter of a century later. In 1998 Billy was granted the honorary degree of Doctorate of Laws from Babson College, one of the local hosts of the PMC, in recognition of his entrepreneurship and total personal dedication to this wonderful act of humanity.

The Jimmy Fund

The Jimmy Fund was established in the late 1940's in Boston. Its original mission was to provide support for a sick boy nicknamed "Jimmy." He was a fan of the Boston Braves baseball team (who have since relocated to Milwaukee and then again to Atlanta). A radio-broadcasted plea for donations for a television set in his hospital room, so that he could watch his local heroes, caught on with extraordinary enthusiasm. A stream of small denomination checks soon followed. This revenue flow evolved into a flood of one-dollar to multi-million dollar donations over the last six decades.

The exact identification of "Jimmy" remained a secret for nearly a half-century. Given the relatively primitive state of medical technology way back then, it was a pretty safe bet that this poor lad had quietly passed away. Ironically, his true identity was revealed in the early part of the twenty-first century. Indeed, he is still alive and healthy, living a modest but comfortable lifestyle in the state of Maine.

Over the course of the last half of the 1900's and into this current century, The Jimmy Fund has become a homespun and enduring model of community giving and an outstanding example of an organizational model for charitable contributions for the purpose of combating a dreadful enemy. In this case the enemy has evolved from cancer among children to cancer among all humans.

In 1953 Tom and Jean Yawkey, owners of the Boston Red Sox, designated the Jimmy Fund as the official charity of the Red Sox. Many high-profile and not so high-profile professional athletes from the Boston sports community, especially the Red Sox, as well as highly recognized citizens from the business, entertainment, and political arenas have repeatedly stepped forward to support this wonderfully embraced local piece of the Boston societal landscape.

The Dana-Farber Cancer Institute

In 1947 Dr. Sidney Farber established the Children's' Cancer Research Center in Boston, introducing the first research program for chemotherapy for children with cancer. This organization, presently name the Dana-Farber Cancer Institute is regarded as one of the top research and cancer care facilities in the world. This institution, affiliated with the Harvard Medical School, specializes exclusively in the research and treatment of cancer. The mission statement of Dana-Farber contains the following language:

… [provides] expert, compassionate care to children and adults with cancer while advancing the understanding, diagnosis, treatment, cure, and prevention of cancer and related diseases

… provides training for new generations of physicians and scientists, designs programs that promote public health particularly among high-risk and underserved populations

… disseminates innovative patient therapies and scientific discoveries to our target community across the United States and throughout the world.

The Pan-Massachusetts Challenge Today

In 1980 the thirty-six athletic pioneers combined to raise $10,200 earmarked for the support of cancer research. Over two days they biked 192 miles from Sturbridge to Provincetown. In 2005 approximately 4,000 cyclists (including 189 cancer survivors) participated in the Pan-Massachusetts Challenge. Their combined contributions topped $23 million. They have come a long way.

The PMC is the largest single contributor to the Jimmy Fund, providing approximately 46 percent of their annual revenue. It is the single-most successful athletic fund raising event in the nation. A most impressive fact is the efficiency of this multi-million charitable enterprise. Over 99 percent of all donor contributions are passed along to the Jimmy Fund.

There are currently a variety of routes in addition to the original 192 mile trek from Sturbridge to Provincetown. On Friday evening Nichols College, not far from the original departure point of Sturbridge, provides free weekend parking, as well as spartan campus housing to riders at a nominal cost. Babson College in the Boston suburb of Wellesley also offers free parking and overnight accommodations for the participants in their Center for Executive Education at a somewhat elevated price. On Saturday night, food and lodging are provided for the participants at the Massachusetts Maritime Academy, located on the shores of the Cape Cod Canal. These three nodes on the overall PMC network allow cyclists to select from a number of routes ranging from roughly 70 miles (Mass Maritime to Babson) to the full length of approximately 200 miles (Sturbridge to Provincetown).

No major event such as the Pan-Massachusetts Challenge could be successfully executed without the tireless efforts of volunteers. In 2005 alone there were approximately 2,200 people who assisted with on-the-course directions, handling of refreshments, etc.

In addition to the generous hospitality of the academic institutions and the individuals who selflessly devote their time, there are many corporate sponsors who donate provisions to the cyclists and to the volunteers. In the words of a veteran rider, "The support of the tireless ride

volunteers along the route was outstanding. The food at the water stops, at the Mass Maritime Academy, and at Provincetown was plentiful and delicious. The inspiration of seeing the cancer survivors along the route cheering for the riders was awesome."

The Growth of the Pan-Massachusetts Challenge

Since its inception in 1980 the Pan-Massachusetts Challenge has generated more than $145 million in funds devoted to the research and treatment for cancer passed through The Jimmy Fund along to the Dana-Farber Cancer Institute. In 2005 alone PMC raised approximately $23 million for this worthy cause.

THE ASSIGNMENT

A table of the time series of the number of participating cyclists and the total amount of contributions is shown in Exhibit 1 (available by request of the author).

1. a. Generate linear, quadratic, and exponential trend equations for the annual amount of contributions to the Pan-Massachusetts Challenge over the life of its existence.

b. Rate the quality of fit for each of these mathematical models by placing a check mark in one cell of the each row of following table:

Quality of Fit:	**Pretty Good**	**So-So**	**Not Very Good**
Linear model:			
Quadratic model:			
Exponential model:			

2. a. Generate linear, quadratic, and exponential trend equations for the annual number of cyclists riding in the Pan-Massachusetts Challenge over the life of its existence.

b. Rate the quality of fit for each of these mathematical models by placing a check mark in one cell of each row of the following table:

Quality of Fit:	**Pretty Good**	**So-So**	**Not Very Good**
Linear model:			
Quadratic model:			
Exponential model:			

3. a. Generate linear, quadratic, and exponential regression models for the annual amount of contributions to the PMC vs. the number of riders over the life of its existence.

b. Rate the quality of fit for each of these mathematical models by placing a check mark in one cell of each row of the following table:

Quality of Fit:	**Pretty Good**	**So-So**	**Not Very Good**
Linear model:			
Quadratic model:			
Exponential model:			

4. The managers of the Pan Massachusetts Challenge have set goals of 4,000 riders and a total of 24 million dollars in contributions for the year 2006. Based upon the results of your mathematical modeling efforts, so these goals seem achievable?

RESULTS

The results for the first go-around of teaching this case, including the nonlinear time series and regression models and projections for short-term numbers of riders and total value of contributions, and how these projections compare to the goals of the Pan Massachusetts Challenge management team were very impressive and encouraging. More importantly, the students sincerely appeared to enjoy the story of the PMC and the exercise of grinding through the assignment. The fact that they seemed to learn a great deal and develop an appreciation for simple trend projections and linear regression analysis was indeed a bonus.

The full copy of the case, the data set, and the teaching note for the case are available from the author.

REFERENCE

[1] Waner, S., Costenoble, S. *Finite Mathematics and Applied Calculus*. Belmont, CA: Thomson Brooks/Cole, 2004.

TIME FOR KIDS MAGAZINE: THE MAGAZINE PUBLISHING INDUSTRY

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ABSTRACT

TIME For Kids Magazine (*TFK*) is a news magazine published weekly during the elementary and middle school year. Its issues were accompanied by a teacher's guide that connected to the classes' curricula. While its subscribing teachers held *TFK* in high regard, general awareness of the product was lacking. *TFK* was a publication delivered to schools and therefore was not permitted to run advertisements as a traditional magazine would. Because of this *TFK* created sponsored programs for advertisers, which could be purchased and shipped along with the weekly issues to the classroom. Given the current state of *TFK*, decisions needed to be made in many important areas.

OVERVIEW OF THE INDUSTRY AND ITS STRUCTURE

In-class magazine publishing was a sub-segment of the magazine publishing segment of media industry. In-class magazines were news/general interest magazines that were distributed into classrooms in elementary, middle school, and/or high schools. Various editions were produced to ensure that the content found in the issues was educationally relevant to the grade that had subscribed. These issues provided students with current event and non-fiction articles that tied into the teacher's curriculum. These magazines were typically published weekly during the academic school year and did not run during weeks where most schools were closed (Christmas and Easter break). Subscriptions to in-class magazines could be purchased by the teacher of that particular class and they were not available on the newsstand. The average cost of a class subscription (25 children per class) was roughly $82.00.

Products

For the in-class magazine industry, there were two main types of magazine products that were created, sold and distributed. They were Weekly Issues and Sponsored Programs. Both the weekly issues and the sponsored programs were distributed into the classroom to the students, and each type of issue had a teacher's guide which outlined possible lesson plans, activities, and ways a teacher could use the in-class magazine as a valuable part of the curriculum. The content found in these magazines contained news, current event, and general interest related articles. The magazine's content (weekly and sponsored issues) was always educational and typically included a game or puzzle for the students. Weekly Issues referred to the news issues that the magazines published on a weekly basis. In-class magazines published multiple editions of the weekly issues, whose editorial content was geared towards the grade(s) the edition serviced. Sponsored Programs referred to the programs that advertisers could purchase that were created by the marketing team of the in-class magazine. Once a class subscribed to an in-class magazine, any sponsored program an advertiser purchased that year to go to a specific grade

edition(s) would also be distributed to the class along with their weekly issue. Advertisers were given the opportunity to run a sponsored program for any week that the weekly issues were published.

Marketing/ Advertising and Sales of Sponsored Programs

The marketing and sales teams were responsible for developing, selling, and creating the sponsored programs that were sold by in-class publications. The weekly issues were written and created by the editorial staff and operated completely separate of the sponsored programs. It was the job of the sales and marketing department to find advertisers and get them to purchase a sponsored program. Sales representatives would meet with potential advertisers and explain what their in-class magazine was capable of. Once an advertiser showed interest, the marketing department would create a proposal that would suggest possible ideas for sponsored programs that the advertiser could purchase. Once an advertiser purchased a sponsored program the marketing department would begin to develop it.

Customers

In the in-class industry segment under study there were three main customers targeted: students, teachers, advertisers, and parents. Paying attention and fulfilling the needs of all three of these customer profiles was extremely important to be successful in this market. Teachers varied in age and were both men and women. The students were both boys and girls in grades Kindergarten through 7th. Potential advertisers were both large and small companies who looked to market a product, service or gain public awareness of a corporate initiative. All subscribers were located in the U.S., but the location of advertisers spanned across countries.

Circulation: Renewals and New Business

Circulation was the focus of the Subscription Sales department of a magazine. This department sought to increase subscriptions sales. For an average in-class magazine, 46% of magazine revenue stemmed from circulation. For in-class magazines subscriptions were purchased through direct mail, renewal campaigns, and the Internet. Their objectives were to deliver the circulation required of the magazine while maximizing circulation net profits.

Organization and Staffing

Magazine staffs were typically divided into 2 segments – Publishing and Editorial. The editorial department was responsible for writing and designing all of the content found in the magazine's standard issues, not necessarily the sponsored programs. The publishing department typically consisted of a Marketing/Promotions department, Sales department, Production department, Finance department, and a Subscription Sales department.

Production and Distribution

Production was physically creating, printing, and distributing the magazine. Production costs represented the physical costs of getting the magazine to the reader. These costs included paper, printing, and distribution. Production specifications, such as paper stock and trim size, determined the look and feel of the magazine. Changes to production specifications could greatly alter the costs of producing the magazine.

Industry Opportunities & Threats

The industry's opportunities included the cost to print on certain weights paper has been reduced, more companies are taking up initiatives geared to children, increasing number of sweepstakes/ contest entrants amongst children, and easy to transition an in-class magazine to follow national education standards. Threats included increased competition from other in-class magazines**,** **s**chools cut funds used to order in-class subscriptions**,** advertisers spend less on sponsored programs**,** and increasing cost of paper, printing and distribution

TIME FOR KIDS MAGAZINE

Using the most current news and real-life, non-fiction articles, *TFK* connected 4.1 million kids to the world every week. Delivered directly to classrooms, *TFK* was a fun, interactive way to motivate kids to read, develop their critical thinking skills, and ultimately inspire a confident, life-long curiosity in the events of the world around them. *TFK*'s mission statement was as follows:

> *TIME For Kids brings real news and enlightening information to young people so that they develop a lifelong interest in, and a connection to, world events. TFK enables its readers to become literate, critical thinkers and informed, responsible citizens*.

Comparative Competitive Position Evaluation of TIME for Kids and its Competitors

The major participants in the in-class magazine industry included *TIME For Kids*, Scholastic, and Weekly Reader. Both Weekly Reader and Scholastic News were very strong in the product category and made sure that the editorial content found in both the weekly issues and the sponsored programs was written in an appropriate manor for the grade(s) the edition serviced. Both competitors also had many editions (Weekly Reader – 17, Scholastic News – 5), which allowed them to really tailor the content in the issues even more so to meet the curriculum standards of the serviced grade. Weekly Reader also published 15 other student magazines, which were specific to certain subjects such as their *Current Health* magazine and their *Science Spin* magazine. The competitors also did an excellent job of making it clear which edition serviced which grade(s). Weekly Reader and Scholastic News both included the grade each issue services on the cover (either front or back) of that edition. When paired against their competitors, *TFK* did not do as good of a job at having the teacher's guides contain lessons that directly corresponded with the appropriate grades curriculum. *TFK,* Weekly Reader, and Scholastic all did an equally good job at censoring certain news topics in the editions that were distributed to the younger grades.

In comparison to its competitors, *TFK* didn't do as good a job of making sure the editorial content found in the weekly issues was written in an appropriate manor for the grade(s) the edition serviced. *TFK* was weaker than its competitors in that they had a much smaller number of editions (three). *TFK* also did not make it clear which edition was responsible for servicing which grade. *TFK's* three editions, Big Picture, News Scoop, and World Report did not tell readers which grades each edition serviced, which was something both of their competitors did. The issues did have the edition name on the cover. This could confuse both students and parents. Teachers would be aware of which editions serviced which grade because they had placed the subscription and this information was clear on the order form.

TFK's sponsored programs were weaker than the competition at providing editorial content that was relevant to the grades the issues serviced. Sponsored programs were at times sold and distributed to multiple editions without having different editorial content for each. This was because the publishing division of the magazine (marketing, sales, and business office) created the sponsored programs and did not have an editorial staff that serviced them directly. Freelancer writers were hired on a per program basis and were very costly. If *TFK* was to create grade appropriate editions of the sponsored programs for the instances when an advertiser purchased across editions, it could potentially cost tens of thousands of dollars. *TFK* did not mention anywhere on the cover of the sponsored programs which grade they were servicing or for that matter which edition it was servicing (the weekly issues placed the edition name on the cover). Compared to the competitors, *TFK* did a poor of a job at having the teacher's guides of the sponsored programs (if a teacher's guide was a component of the program) contain lessons that directly corresponded with the appropriate grades curriculum. *TFK* was stronger than its competitors in its ability to meet the advertiser's needs while maintaining *TFK's* integrity.

In the area of Marketing/Advertising and Sales, *TFK* did a fair job of explaining how the in-class magazine business model worked and quantifying the value of a sponsored program to advertisers. This was a difficult task in general for an in-class publication since the majority of advertisers were accustom to purchasing ad pages in traditional magazines. *TFK's* competitors seem to be doing a better job at explaining the business model and quantifying a sponsored programs value to an advertiser. This was solely based on the fact that over the last 2 years both Weekly Reader and Scholastic News had won business that *TFK* competed for as well. This proved that the advertiser wanted to run an in-class program but chose to do it with *TFK's* competitors, making it fair to assume that the competing books better explained the model and/or the value of running a program. *TFK* did not sell as many sponsored programs as its competitors did in 2004-05. This fact was directly related to *TFK* having a junior sales staff with unusual hours that didn't have much experience selling sponsored programs. Another factor that quite possibly contributed to the lack of sponsored programs sold was the marketing team's inability to sponsor program proposal requests for advertisers quick enough. This was mainly due to the smallness of *TFK's* marketing department.

TFK did fall short of fulfilling the teacher's need to have the curriculum in the teacher's guides and student magazines for the weekly issues and sponsored programs meet national education standards. This was something that the competition did well. While *TFK's* content for both weekly and sponsored issues did adhere to what the appropriate grade was covering loosely, *TFK* did not specifically state how each lesson in the teacher's guide coincided with what a teacher needed to be covering. Because of this, *TFK* was not used as much as the competitor's magazines were as part of the teacher assigned homework. *TFK* was very strong at making sure the content in both the weekly issues and the sponsored programs had a good balance of educational and fun content for its customers. Students enjoyed reading and using the issues because the magazine incorporated games and activities into the content, while both teachers and parents were happy because they were able to get across important educational messages to the children.

In comparison, *TFK's* competitors' content did not balance educational and fun content as well as *TFK*. The concepts found in the competitors sponsored programs were much dryer and a lot

less creative in comparison to *TFK*. The articles in weekly issues were also less engaging, and were not always as current as *TFK's*. In the past, Weekly Reader had used the same exact cover image and cover story concept that *TFK* had published the week prior. *TFK* was equal to the competition in regard to the number of sweepstakes and contests they ran as part of their sponsored programs, however all could do better.

TFK was also very strong at proving to parents that *TFK* was a trusted source for information and that the magazine operated with the highest of ethics. *TFK* made sure that the content found in the weekly issues was covered responsibly in cases where an article might deal with a very sensitive topic/issue. *TFK* had received numerous letters from teachers and parents, thanking the magazine for teaching their students/children about events that were going on in the world without having them lose hope. Another example of how *TFK* exemplified educational responsibility was how they handled the running of the sponsored programs. *TFK* had turned down advertisers who wished to purchase a sponsored program in the past if they felt the advertiser's message was too promotional, or not appropriate for the classroom. For example, Trident had approached *TFK* several times to create a program, but the magazine would not partner with Trident because their product was gum and gum wasn't allowed to be chewed in school. By being selective about whom *TFK* allowed to sponsor a program, the magazine had been able to increase teachers and parents trust alike.

Both Weekly Reader and Scholastic News did not have the same level of trust from teachers and parents that *TFK* held. The competitors both ran several sponsored programs that were very promotional throughout the year. This had upset both teachers and parents in the past who have felt that the competitors were taking advantage of their ability to reach a large number of children to advertise. *TFK* was stronger than its competitors at having its issues foster a parent-child relationship. Eighty percent of *TFK* subscriber parents said that they have a 15 minute conversation with their children based on something they've read in *TFK* that particular week. *TFK* was stronger than its competitors at having the sponsored programs increase sales of the advertiser as was exemplified with the Toyota program for their Sienna vehicle. *TFK* as well as its competitors provided research to its advertisers after the sponsored programs had run. All, however, did not ever conduct pre-research which could significantly help the value of the sponsored program in the classroom. *TFK* was stronger than its competitors at having the content of the sponsored programs be unique. The programs created by the competition tended to use bland colors and didn't really cover topics that students and teachers found to be highly interesting.

In the Circulation and Consumer Marketing category, *TFK* did well at creating effective renewal/ new business campaigns and direct mail campaigns. They had a steady increase in student penetration from 1997– 2004, growing from 6% to 17% for grades K-6 in the U.S. Scholastic News also did well at creating effective renewal/new business and direct mail campaigns. Scholastic News saw their student penetration increase between the years of 1997-2004 from 14% to 20% for grades K-6 in the U.S. Weekly Reader was weak at creating effective renewal/new business and direct mail campaigns. Weekly Reader saw its student penetration decrease between the years of 1997-2004 from 22% to 17% for grades K-6 in the U.S.

TFK was equal with its competitors when reviewing the clearness and conciseness of the subscription order forms. *TFK* was also equal to Scholastic in regard to running the optimal amount of campaigns for renewals and new business. Both *TFK* and Scholastic were stronger than weekly reader in this area. *TFK* as well as both of its competitors seemed to have strong customer service departments. Of the three, *TFK* had the lowest circulation, 4.1 million, while Weekly Reader had 4.9 million subscribers and Scholastic News had 5.6 million subscribers between K-7th grades in the U.S. The quality of *TFK's* editorial staff was strong, in comparison to its competitors, which were fair. This was based on research conducted by an outside firm that surveyed both teachers and students on the content of each in-class magazine. Eighty percent of teachers used *TFK* as part of their homework assignment and 88% took *TFK* home to read.

TFK had a strong, although small marketing team who had some experience at creating sponsored programs. The quality and content found in the sponsored programs over the 2004-2005 school year was excellent. All advertisers who sponsored programs in 04-05 received excellent results according to *TFK's* research study completed in November 2005. *TFK's* competitors seemed to have fair marketing departments. This was based on the feedback *TFK* received in a focus group that was conducted which gave kids *TFK*, Weekly Reader, and Scholastic News and got their views on all three. The majority of children felt that the *TFK* sponsored programs were the most fun and interesting of the three. Since the content of the sponsored programs was a result of the marketing department's ideas and execution, it was fair to say that both Weekly Reader and Scholastic News were not as strong as *TFK* in this area.

TFK was weak in their financial practices. *TFK's* pricing methods were inconsistent over recent years and they did not seem concerned with maximizing margins on the sponsored programs that they sold. *TFK* also did not keep detailed records of the costs of past programs or what their profit/loss was on each. There was no available information regarding the financial practices of *TFK's* competition. *TFK's* sales staff was fairly weak in comparison to its competitors. Both Weekly Reader and Scholastic News sold 11 and 13 sponsored programs during the 2003-04 school year respectively. *TFK* only sold 7. *TFK's* lack of sponsored programs sold was a result of having a 2 person sales staff whom of which both worked 3 days a week. Both sales people did not have any experience selling sponsored programs. Furthermore their commission was based on *TFK's* total sales and each rep did not have an individual amount of sales that they had to meet, so there was no real accountability by the sales team.

TFK was strong in the key areas related to production. *TFK's* issues shipped in bundles and paid a low postal rate since it qualified as an educational periodical. The quality of all *TFK* issues was excellent and the production/printing costs behind them were reasonable. *TFK* just renewed its print contract (effective 2006) and received a 10% discount in comparison to what they were charged in 2005. Little was known about the production practices of the competition. Since *TFK* is a Time Inc. publication and Time Inc. was the leading magazine publishing company at the time, it was fair to assume that *TFK* received a lower rate with their printers as part of the contracts negotiated by Time Inc. in comparison to the competition.

Management of TFK needed to differentiate *TFK* from the competition and so achieve a winning edge over competitors within an intensely competitive and rapidly changing industry.

DIGITAL CAREER PORTFOLIO DEVELOPMENT FOR SCHOOLS OF BUSINESS

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ABSTRACT

This paper includes two main themes answering basic questions of "Why" and "How" that are asked when discussing the development of career portfolios during a student's academic program. The reasons why portfolios in general should be created are discussed primarily in the Rationale section. Following this is a description of a current program at a state university where portfolios are integrated into the School of Business curriculum. Finally there is an outline of the portfolio development process with concrete suggestions on the steps to follow, the design process, and modes of distribution.

KEYWORDS

Digital Portfolios
ePortfolios
Evaluation Methods
Presentation Design
Self-Appraisal

DIGITAL CAREER PORTFOLIO DEVELOPMENT FOR SCHOOLS OF BUSINESS

RATIONALE

Students are sometimes oblivious of the structured academic paths that lead them from one level of knowledge to another. Unless they are unusually reflective and deliberately trace their intellectual growth, most students enroll in prescribed courses as directed. Somehow the diverse accretion of knowledge is supposed to congeal into the whole, with students emerging as educated people able to do self appraisal, having absorbed and connected all of those separate learning experiences.

Doing a continual formal assessment of their work increases the students' ability to comprehend the learning continuum. Developing portfolios serves this purpose and can be started at any point. Students collect and preserve their work in creative accumulative projects, reflecting and assessing their learning during the process. The more traditional paper-based portfolios have given way to digital portfolios, also referred to as electronic portfolios or ePortfolios. This type of portfolio uses students' technological skills to gather and preserve artifacts in more permanent forms. Students may create individual course portfolios as well as academic career portfolios as they progress through their educational programs.

Digital portfolios provide a connection or a pathway, moving the student along from the classroom environment into chosen careers. Developing an innovative and original professional digital business portfolio constitutes a lasting comprehensive experience for students, adding to their professional development. Continual reflection upon their work arms them with more confidence in their own competence and worth as they embark on their professional careers. Business schools in particular strive to develop students into sophisticated knowledge workers, able to analyze processes. Examination of their work in the portfolio enables students to "re-calibrate, according to Poore [2]) and to enhance their growth by analyzing their work objectively.

According to Williams and Hall [4] students can start "interesting conversations" in employment interviews that are aided by showing concrete examples of their competencies in their portfolios.

Digital career portfolios are basically collections of artifacts used to validate claims made by the creator. These artifacts are in a creative variety of formats: text documents, Web pages, presentations, research papers, assessment instruments, original projects, academic or external teamwork, internships, presentation videos, certificates of achievement, spreadsheets, databases, digital images, and multimedia demonstrations. These digital portfolios serve the career student population, particularly information technology (IT) professionals, encouraging them to develop technologically-creative resumes. The artifacts support the students' statements of proficiency in their chosen fields. Prospective employers, especially those in information systems (IS) recruiting, look for technical knowledge and proof of technical competence. Portfolios in digital form showing creative technical projects aid the student-interviewee to both tell about and show competencies.

In short, a portfolio is a demonstration of skills and abilities, containing evidence of growth and competence. Satterthwaite and D'Orsi [3] state that a portfolio is a collection of easily portable artifacts that serve to validate claims people make about themselves. Portfolios can be learning tools, job search tools, and career growth tools. The purpose of the portfolio to some degree dictates the artifacts collected as well as the format of the presentation design.

Digital career portfolio development was implemented in several courses in Management and Information Systems in the School of Business. Students created digital portfolios as an integral part of their learning experience in addition to contributing to their preparation for internships, cooperative work experience, or job searches upon graduation.. They were required to keep a journal of their progress and submit this weekly to the professor along with the portfolio segment assigned for the week. These types of activities aided in both teacher and student assessment of course work.

DESCRIPTION OF PORTFOLIO DEVELOPMENT PROCESS

While the specific steps followed for each course were sometimes different, depending on the purpose and design of the portfolios, there were commonalities among all courses and types of portfolios.

Introducing the Process

Initially students were introduced to the concept and purpose of portfolios for each course. General procedures and calendars were presented to guide students when building their portfolios. Whether course or career portfolio, each type had different steps to create it. Examples of completed portfolios were shown to enhance students' understanding, to spark their ideas, and to generate questions regarding the process.

Introducing Terms and TheirUse in Development

Metaphors and Navigation: Students developed the concept of their portfolio designs and presented them for brainstorming and approval. These concepts included defining the visual metaphor the portfolio would follow graphically and describing the structure the portfolio would adhere to. Visualizing a graphic metaphor such as a book or a Web site aided students in creating the organization, storyboard, behavior, look, and graphic feel of their portfolio pages as well as designing effective navigation.

A linear portfolio would be viewed in a sequential way, one page at a time. There might be a cover, table of contents, chapters, and an order to the portfolio contents like a book. A portfolio using a Web structure could be viewed in any order the user chose, having the ability through navigation to jump from one content area to another.

Templates: Students built templates for their portfolio cover and pages in the software in which they had expertise, such as Microsoft PowerPoint, Adobe Photoshop, or Microsoft Word. These templates became the pages of their portfolios on which they would place the text, video, images, and links to document that comprised their portfolio content. Special attention was given to using color creatively, creating intuitive navigation, and ensuring a professional appearance.

Since the portfolios were designed as primary digital documents to be viewed on the computer, screen design, resolution, and legibility issues were introduced. Web-safe colors and system fonts were selected as universal design elements for consistent viewing across platforms. Graphics were created or optimized for screen viewing at 72 pixels per inch (ppi). The dimension of the portfolio pages were designed for computers with a resolution of 800 by 600 pixels.

Artifacts: Documents, projects, and video that students felt represented their best works and abilities were collected as artifacts for the portfolios; then they were stored digitally on hard drives and on the portfolio organization and storage space given in Blackboard®, the course management program used by the university. The instructor reviewed students' selections periodically, and students were encouraged to select or create effective artifacts.

In addition to collecting and storing the original files, paper artifacts were digitized by scanning and all digital files were optimized so that two files for each artifact were saved. Optimization included sizing and using image compression to create files that would view efficiently on screen in the portfolio presentation.

Individual and Web Tutorials

Element K [1]online tutorials were made available to the students in the computer labs. One-to-one support with software was provided where required. Students needed special help in evaluating their academic experiences to edit their artifacts or create their resumes. Step-by-step guides were given to help students prepare their multimedia (i.e. digital video, audio, and animation) artifacts for inclusion in their portfolios.

Incorporation and Reflection

Students arranged their prepared artifacts in their portfolio templates to construct the portfolio. In course portfolios, students added reflective text with each artifact to recall their experience in fulfilling each assignment.

Grading and Presentations

Students handed in their portfolios at mid-term for interim assessment as well as giving a presentation of their concepts and progress to their classmates for peer critique. Final grades were given on the basis of creativity, format, technical competence.

Evaluation Methods

Portfolio evaluation was ongoing during the semester, done by both peers and faculty. Students continued to collect, create, and prepare their artifacts. They worked in collaborative teams for informal critiques from their peers. Instructors gave formal evaluation to these portfolios using rubrics which had been explained to the students at the onset of the program. These rubrics added an extra set of benchmarks and objective means of assessing for peer evaluation. Teams would compare their work against the detailed items in the rubrics.

Distribution

When their portfolios were completed, students created a final CD or DVD for distribution.

CD/DVD Enhancement

Students designed CD labels, jewel case inserts, and collateral pieces delivered on paper toward their final presentation of the portfolio and for grading.

Design considerations

Software: The software chosen for the creation of the digital portfolios was different for each course. The common challenges were that the resulting portfolios had to meet the criteria of being cross-platform, easily distributed, and in a common format that most viewers would be likely to open successfully.

In some cases the software was part of the course design, where all students used a common program, Macromedia Director, to build their interactive portfolios. In other cases the students were encouraged to build their portfolio templates in software in which they already had competency, such as PowerPoint or Microsoft Word. In these courses students constructed their final portfolios in the Portable Document Format (PDF) using Adobe Acrobat. The completed page templates were exported, saved, or printed to PDF. They were then assembled into a single PDF portfolio document for insertion of hyperlinking navigation controls and appropriate placement of multimedia files.

Effective formats

The digital portfolios were designed to be viewed primarily on the computer screen. This meant that the artifacts were prepared to the monitor resolution of 72 ppi. Also the dimensions of the templates were designed to view completely on a standard screen without scrolling using 800 by 600 pixels. Documents or artifacts that could not be presented effectively in this format were prepared and linked to the electronic document to download for viewing outside of the portfolio environment.

Use of multimedia

The ability of students to demonstrate their skills and experiences through motion media was one thing that made digital portfolios more functional than traditional paper portfolios as both a course and a career tool. Multimedia added an important dimension to the digital portfolios. It was relatively easy to prepare, incorporate, and present multimedia in the portfolio environment. Students who were not familiar with the creation or preparation of multimedia required more support and instruction in creating this type of artifact.
The types of multimedia used included video, animation, Flash documents, and audio. Adobe Acrobat and Director, two programs used to create the portfolios, both support multimedia. Audio and video were edited and formatted using Final Cut, iMovie, Premiere, or Pinnacle Studio. Animation was created in ImageReady or Flash and formatted in a video program or QuickTime Pro.

Digital File Storage:

Digital portfolios and the collection of full resolution digital artifacts can make the planning and selection of storage media one of the first decisions required to implement digital portfolios in a course. Storage media needs to be portable, easily accessible and affordable, whether purchased by the student or the school.

Storage for artifacts should be permanent and redundant so that if one drive or disk fails, students will have a backup and not lose any of their artifacts. Moving files back and forth among class, computer labs, and desktop was done effectively with CDs and USB flash drives. Some students used 100- 750 MB Zip disks while some had file sizes that required DVDs. Students had limited local network drive space for temporary storage of student work in the labs and were also allocated space on the portfolio section of Blackboard® as previously noted.

The finished portfolios were planned to fit on a standard CD with a 700MB capacity, although some students with large motion files prepared their portfolios for DVD disks. Students exercised further creativity by designing CD labels and jewel case inserts. The size of the storage media depended on the artifacts the students collected. If there was heavy use of video or other multimedia, more storage space was required than for primarily text documents.

CONCLUSION

Compiling their digital portfolios was a strong asset in the students' learning paths. It served not only as an archive for precious material that may be otherwise lost over the years but it also served as an organizing principle. Students remember what they do and what they produce. Their portfolios captured a moment in time when the students were acquiring the skills and competencies needed for their careers. The reflections they made when collecting and archiving their projects allowed them to make cohesive connections between concepts learned in various courses.

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A SURVEY OF THE PH.D. CANDIDATE SHORTAGE IN BUSINESS SCHOOLS: A PRELIMINARY REPORT

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Abstract

There have been many discussions and articles concerning the shortage of students entering PHD programs in Business Schools. A multitude of reasons have been offered for this "perceived" shortage. The purpose of this study is to identify the reasons for the shortage, and in what specific areas shortages may exist. In this study, we use a survey instrument to examine this phenomenon. The population of this survey will be primarily graduate program directors. Our study should result a better understanding of any shortage and the reasons why such a shortage exists. This paper represents our preliminary findings based on review of the literature and a limited survey of Doctoral Granting Programs in the US.

Key Words: PhD Programs, PhD Students, Business Schools, Shortage of Ph.D. students

Introduction

Discussions of the issue of Ph.D. candidate shortages have been held in many forums during the past few decades. In fact, the number of new business doctorates declined about eight percent from 2000 to 2004 (Business Week, Oct. 23, 2006). To complicate the problem more, not all new doctorates in business enter the academic world. In 2003, AACSB International published an informative study, "Sustaining Scholarship in Business Schools," that discusses the issues of shortages of Ph.D.s, and lists several methods by which schools could address these shortages. In addition, the AACSB website includes an informative section to encourage potential candidates to apply Ph.D. programs. Efforts are being made on other fronts, as well, to address this critical issue. There appears to be disconnect, however, between what the degree-granting universities can and will do and the needs of the market.

AACSB (2003) calls on Ph.D. granting universities to take action to help alleviate this shortage. It is our contention that, while there are many reasons for the shortage, to a large extent, Ph.D. degree-granting universities are part of the cause of this problem. Funding for programs has been reduced. However, with the large number of applicants and excess capacity within Ph.D. programs, perhaps more could be done by these schools to alleviate shortages.

In this paper, first the literature is reviewed of this on-going concern. There is evidence in the research that supports this paper's contention. Next, survey methodology is discussed and results are presented. Lastly, conclusions are offered and summarized.

An On-going Concern

The issue of the Ph.D. shortage is not new. During the 1970s and early 1980s, several articles were written that highlighted the needs of universities to find solutions to the shortages that existed at that time. (See Stunt, 1974; Crum, 1978; and McCullough and Wooten, 1981.) The AACSB International-Association to Advance Collegiate Schools of Business formed a task force in the late 1970s to study the issue. The task force published its findings in 1981. Surveys indicated that there was excess capacity in Ph.D. programs. Drawing from Crum (1981) and the AACSB (1981) studies, Shipley and Engle (1982) highlight the shortage of accounting Ph.D. candidates at all stages of study. They state that "(t)here is one basic conclusion that can be drawn: Academe has excess capacity for producing doctorates in accounting and therefore could benefit from marketing efforts."

More recently, several articles have presented evidence that the shortage continues. Davis and McCarthy (2005), Basil and Basil (2005), Marshall, et al, (2006), as well as AACSB International (2002, 2003) all weigh in on the continuing problems with attracting and retaining candidates. Recommendations have been made to alleviate the shortage. One recommendation made by the AACSB study is to cross train Ph.D.s from other disciplines to fill the gaps within business schools. Marshall, Dombroski, and Garner (2006) tested this recommendation for the accounting field. They found that "(u)sing various statistical methods, . . . accounting faculty with accounting doctorates and accounting faculty with non accounting doctorates did not differ with respect to: teaching specialty, rank, tenure status, number of different universities where they taught, or number of years of work experience in public accounting, industry, government, or other work experience." They did find that non-accounting Ph.D.s had more years of experience and held degrees longer than accounting Ph.D.s.

Davis and McCarthy (2005) report a severe shortage in the area of marketing. They use data from the AACSB International (2003) study, and survey marketing doctoral program coordinators and students. Using AACSB International data, Davis and McCarthy (2005) say "(e)ighty-six percent of respondents from U.S. programs reported having a limit on doctoral program enrollments. Among the 23 schools responding to our marketing coordinator survey, more than half were under-enrolled for the most recent year and for the 5-year period from 1996 to 2000. On average, two new students enrolled each year, whereas marketing doctoral program capacity was three students per year." There is a need to understand the shortage from many angles, including what potential candidates may perceive as reasons to attend a Ph.D. program, as well as the needs of degree-granting universities, to see if reasons and needs mesh.

Ph.D.-Granting Institutions' Perceptions

There are several concerns. First, Ph.D. program funding has been reduced, so that deans and program directors have had to accept much smaller entrance numbers.[1] However, there is evidence also of excess capacity, as slots go unfilled. Second, faculty members in recruiting departments are held to the highest research standards by accrediting bodies. As a result, rational choice on the parts of research faculty cause them to emphasize research skills of prospective candidates to assist faculty with their research, and to create as strong a pool of graduates as possible, in their estimation. However, as rational as these choices are from the degree-granting university's perspective, this structure may not be optimal from the hiring market's perspective.

In the production of Ph.D.s, there is a perceived mismatch in market needs. For the most part, Ph.D.-granting business schools are top-tier research universities. This level of school is supported by rankings

[1] One school reported in a phone conversation with one of the authors that their program had lost over 100 Ph.D. student slots in the past five years.

as to where they place their Ph.D. graduates, as well as by the level of academic qualification that their professors are required to maintain for AACSB International accreditation. Therefore, these schools look for top research candidates and turn down good potential teacher/researchers. However, most other universities need teachers who research and publish, not researchers who teach. There is a difference.

Researchers who do end up at a more teaching-oriented business school can find themselves frustrated with the amounts of teaching, not leaving time for the research that led them into higher education in the first place.

Students get frustrated with the lack of attention such professors offer to them. This can lead to another problem, as undergraduate and masters-level students experience poor quality interaction with their faculty. As a result, this translates into poor customer service that can cause these students not to want to continue in higher education.

Universities' and Market Perceptions

Hiring Ph.D.-qualified faculty in some disciplines is particularly difficult and expensive. Many undergraduate- and masters-level universities do not have access to student-teachers, and therefore, use adjuncts as they can recruit them. Whereas many adjuncts can be much better teachers than regular, full-time faculty, the market perceives the extensive use of adjunct faculty as a weakness on the part of universities. Even accrediting bodies limit this source of teachers, who cannot devote much time to participate in the life of the university and are "only" professionally qualified.

There are other potential reasons for the shortage. Ph.D. programs often wait for students to go to them, thereby missing opportunities to encourage a broader array of students to apply. Career fairs for undergraduate and graduate students seldom advertise careers in higher education. The aforementioned AACSB International Ph.D. area of their website does make mention of some efforts to recruit students directly. However, deans, MBA and other masters-level program directors, and faculty could be rich sources of potential candidates, if Ph.D. granting schools marketed to them, asking for nominees. Included in this marketing effort could be information on cycles of recruitment, student recruitment areas, required skills and aptitudes, as well as questions concerning potential for success and completion. The one exception is the Ph.D. Project sponsored by KPMG that focuses on introducing minority students at undergraduate and master levels to Ph.D. programs and encouraging them to attend business doctoral programs. However, Ph.D. Project is more of an exception than the rule.

There are also shortages of Ph.D. graduates, once the decision has been made to attend a Ph.D. program. There are Ph.D. candidates who do not finish. Some do not pass their comprehensive exams; some quit before working on their dissertations; while others never complete their dissertations. Using "ABDs – All But Dissertation" to teach courses may hinder progress on dissertations, especially for those who may prefer teaching to research, anyway. Time and motivation become negative factors preventing completion. However, ABDs are a ready source of part-time teachers who do what they are asked, sometimes out of fear of saying "no" or due to the need of income.

Methodology

The AACSB International website identified 110 AACSB-accredited universities as having doctoral programs. All Ph.D. program directors were contacted as listed on the website. Of the 110 program directors, 54 of them responded to our survey questionnaire regarding the nature and status of the fall 2006 entering class of students for their Ph.D. programs.

Analysis

The general findings are shown in Table 1. Based on the responses received from the 54 program directors, a total of 11,448 applications for Ph.D. programs were received. Of this number, only 1126 (or about 10 percent) were accepted by the universities. However, only 688 students started the programs (only about six percent of the total applicants).[2] Ninety-two percent of all schools accept students in the fall semester only.

Overwhelming, the majority of all schools (78 percent) stated that the main focus of their doctoral program is on research, with the remaining 12 percent indicating that both research and teaching are the focus. However, from the latter group, almost all indicated teaching has a lower priority.

There were nine areas of study listed, most in traditional areas, offered by these schools. Areas of specialization have been aggregated into the major areas of study. They are: Accounting (48); Entrepreneurship (3); Finance (43), including, International Finance, Risk Management/Insurance, and Real Estate Management; Information Systems (30), General Management (35), including Human Resource Management; Organizational Behavior/Organizational Theory (16); Marketing (48); Operations Management (23); Operations Research/Management Science (14), including Statistics; and Policy/Strategy (18). In addition, very few schools indicated that they offer specializations in areas such as Ethic/Law, Tourism, Health Care Management, and System Dynamics. However, several PhD directors indicated that Economics is housed within their schools, as well.

The most popular major was Finance (128 students), followed by Management (105), Accounting (88), and Marketing (85). However, if one considers areas such as OB/OT under Management, then this area would be the most popular, with a total of 133 students entering in 2006. Of course, popularity of majors such as Finance and Accounting is understandable, since during the last few years, Ph.D. graduates in these two areas have been in high demand. This environment has attracted new students who expect to command higher salary than students who graduate from other majors. Table 1 shows details in terms of numbers of students for each area of study and specialization.

Demographics are interesting, as well. First, although only 38 program directors responded to this question, according to the survey, about 34 percent of all new doctoral students are women. Therefore, the ratio of male to female students in business programs is two to one. The same ratio existed in 2004, as well. In addition, the survey found that over half of Ph.D. students (535) in the 2006 entering class were not US citizens, as in 2004. This is interesting, since it is perceived that under the current political climate, there are fewer students entering the US to pursue graduate study. Third, the survey reveals that about 50 percent of the entering class are between 20-29 years old, 42 percent are between 30-39 years old, and only about eight percent are 40 years or older.

Possible Solutions

Ways must be found to reduce the burden of these programs on the Ph.D.-granting schools, perhaps to expect hiring schools to bear part of the cost. For hiring universities, students are “free goods.” The cost of educating them has been borne by the Ph.D.-granting schools, as well as by the taxpayers of many states.

[2] The authors do note that probably there is overlap in the number of applicants, as prospective students applied to more than one school or even program within a school.

One suggestion to help alleviate the shortage of candidates, and to mitigate the cost, is for hiring schools to recommend one or two candidates to attend a Ph.D. program. In return, the hiring schools would help pay at least part of the cost of the student's education, depending on how much the student contributes to the Ph.D. program through teaching assignments, research, etc. In return, the hiring school would expect the newly minted Ph.D. to teach for a period of five years, say, or maybe until tenure/promotion time. Final decisions could be made at that time.

Cohorts could develop that represent a variety of hiring schools and help direct teaching requirements. For example, if there were shortages of organizational behavior, finance, and marketing professors expected in the next five to ten years at the sponsoring schools, emphasis might be put on these areas for the cohort. This type of planning could help Ph.D.-granting schools to know of needs in advance, to assign their faculty accordingly, and to market the program to others who might fill vacant slots.

There are additional solutions that might be tried. Since only about eight percent of Ph.D. candidates are over 40 years of age, there is room to increase numbers from this age group. These are experienced professionals who may even have been adjunct teachers during their career. Therefore, one solution might be to increase the number of part-time Ph.D. programs to address the needs of working professionals. Currently only eleven schools in our survey stated that they have part-time programs. Of these eleven, only two have part-time executive doctoral programs. This additional programmatic offering would enhance career development of many executives who would like to transition into teaching. For example, in Washington, DC, and in other parts of the country, many high-level government employees retire at a relatively young age. They are able to move to another career within normal working years, and can return to school before leaving government employ. Other senior-level private sector employees have expressed a desire to receive Ph.D. degrees, but cannot afford to leave their full time to do so. In addition, this might be a profitable programmatic offering, as these mature students might be able to afford the degree on a part-time basis, as they look forward to their next career.

Another solution may be to train high-level professionals/executives who are reaching the retirement age to be teachers and researchers, without requiring a Ph.D. This is the "bridge model" introduced by AACSB International, or potentially use a model like the one used in some districts in Florida's K-12 systems. In Florida, school systems hire professionals who are unhappy with their current jobs who attend intensive training to prepare them for teaching in classrooms. This maybe applicable to people who have at least a graduate degree (MS, MBA, etc).

Conclusions

The Ph.D. shortage has been long running, at least for several decades, and apparently not abating. Granted, shortages in different disciplines ebb and flow, as salaries and other factors help alleviate deficits over time. The paper has presented evidence of the shortage based on surveys of degree-granting schools, as well as several solutions to the problem.
Importantly, these solutions take pressure off of hiring schools that need good teachers, and also off the Ph.D.-granting schools that must afford these high-cost programs.

Nevertheless, this issue must be resolved in some acceptable manner. Accreditation sets limits on the use of adjuncts, as well as non-Ph.D.s teaching in our nation's college classrooms. As more and more current faculty retire, shortages are only going to get worse, especially in some disciplines. Degree-granting schools and academic departments must understand their roles in supplying the much needed final products trained in appropriate disciplines, methodologies, and research/teacher or teacher/researcher modes to satisfy a hungry market. This discussion must continue until real actionable solutions are found.

References are available upon request from the second author.

TABLE 1

Total No. of Responses	Selectivtiy			Foucs			Age Distribution			Origin		Gender	
	Applicants	Accepted	Matriculated	Teaching	Research	Both	20-29	30-39	over 40	US Citizen	Non-Citizen	Femal	Male
54	11448	1126	688	0	42	12							
acceptance rate		10%		Focus	78%	22%							
Yield			61%										
Actual Yield	6%												
38							50%	42%	8%				
54										321	367		
										47%	53%		
38												172	334
												34%	66%
												Ratio	
Specialization	Acct	Entrep	Fin	MIS	Mgmt	MOT	Mrkt	OB/OT	OM	OR/MS	Strategy		
No. of Schools	48	3	43	30	35	5	48	16	23	14	18	283	
No. of Students	88	2	128	47	105	8	85	28	30	22	19	562	

MEASURING FACULTY AND STUDENT USE OF TECHNOLOGY USING TECHNOLOGY ACCEPTANCE MODEL

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ABSTRACT

The technology acceptance model (TAM) has been used to examine the perceptions of usage, usefulness, and ease of use of technology. This research will apply the TAM model to a college campus to measure the faculty and student acceptance of an online education management system.

INTRODUCTION

Instructors are often encouraged to use technology in their courses. However, there is little systematic evaluation of participation and acceptance, keys to the adoption process. Computers are used more in education today than ten years ago, partly because they have become more affordable, smaller, and more powerful. During this time, student and faculty have developed in concert with the technology. The use of technology, for some, puts the learner at the center of education. Rather than being a passive recipient of knowledge, as happens in a traditional chalk-and-talk lecture, the online student is given tools to research, question, respond, and create meaning from a variety of sources, not just from a professor. Professors themselves have been increasingly engaged in creating new educational systems and resources. The process of education technology adoption is an evolutionary cycle of invention, distribution, teaching, and learning that is completed as graduates go on to participate in education, society and commerce, creating demand, industry, and new inventions of technology.

With many colleges installing new online education management systems, it is important that they understand the factors that make educational technology useful to both instructors and students. This study considers technology adoption issues from the perspective of adult college learners and instructors at a typical four-year college. The issue examined is student participation, and their perceptions of the usefulness and ease of use of WebCT as an interactive online education management system.

TECHNOLOGY ACCEPTANCE RESEARCH

Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) is a social psychology model developed to explain and predict individual behavior. Technology Acceptance Model (TAM) (Davis et al, 1989; Davis, 1989), which is based on TRA specifically explains and predicts the adoption of technology. In general, both models posit that a behavior is determined by the intention to perform the behavior and that actual behavior and intention are highly correlated. Ventatesh et al (2003) have extended TAM to argue that four constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions are direct determinants of behavioral intention and use behavior. These four constructs, they further argue, are mediated by age, gender, experience, and voluntariness of use.

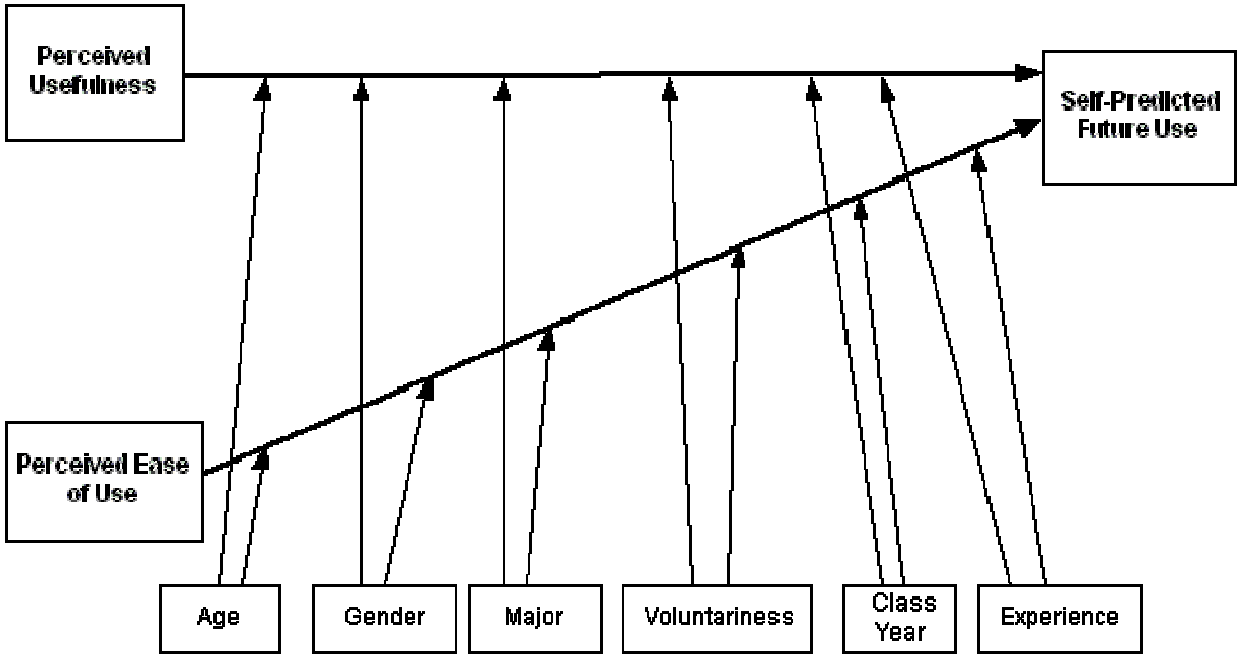
Model and Methodology

The current study poses a model of technology acceptance determined by expectations of future usefulness and ease of use, and by present usefulness and ease of use. Also considered as

independent or moderating variables were age, class year, gender, WebCT experience, voluntariness, and academic major (see Figure 1).

A convenient sample of undergraduate students at a four-year college located in the northeast of the United States of America was surveyed. Respondents completed a questionnaire administered by their instructors on the first day of school. The survey yielded a sample of 368 respondents.

Figure 1: Research Model



Perceived Usefulness

Respondents rated their perceptions of the usefulness of WebCT course management software. The six items consisted of statements to which respondents indicated their degree of agreement on a six-point verbal frequency scale with extremes labeled 'extremely likely' and 'extremely unlikely', with the midpoint labeled 'neither'.

Perceived Ease of Use

The second section of the questionnaire contained six items stating attitudes toward use of WebCT software. Respondents registered their perceptions on the same six-point scale.

Self-Predicted Future Use

The third section of the questionnaire contained one item. Respondents indicated their likelihood of using WebCT software in future. They responded using the same six-point scale that was used in sections one and two of the questionnaire.

Current Perceived Usefulness

The fourth section of the questionnaire was addressed at those who were had used WebCT in prior courses or were using it in the current course. Respondents were asked to record their perception of the usefulness of WebCT on a six-point verbal scale with extremes labeled as

'quite true' and 'quite untrue', with the midpoint labeled 'neither'. There were six items in this section.

Current Perceived Ease of Use

In the fifth section of the questionnaire respondents were asked to record their perceptions of ease of using WebCT software. This section had six questions and the same six-point scale used in section four.

Self-Predicted Future Use

The sixth section of the questionnaire contained one item. Respondents reported their likelihood of continuing to use WebCT in future on the six-point verbal scale that was used in sections four and five.

Demographic data

Demographic status of respondents was collected in section seven of the questionnaire (see Table 1). Data collected included age, gender, class year, academic major, experience using WebCT, and respondents' voluntariness of using WebCT.

Table 1: Demographic status of respondents

Variable	Number	Percentage	Variable	Number	Percentage
Gender			**Experience Using WebCT**		
Male	186	51.1	No course	34	9.4
Female	178	48.9	One course	73	20.2
Total	364	100	Two courses	64	17.7
			Three to five courses	160	44.2
Voluntariness			More than five courses	31	8.6
Voluntary	143	40.9	Total	362	100
Involuntary	207	59.1			
Total	350	100	**Major**		
			Business (mktg, accounting, mgmt)	276	75.8
Age			Economics	13	3.6
Under 21	177	48.5	CIS/CS	12	3.3
21 to 22	128	35.1	Math	5	1.4
23 to 35	46	12.6	Other	58	15.9
36 to 45	12	3.3	Total	364	100
46 to 55	1	0.3			
Over 55	1	0.3	**Class Level**		
Total	365	100	Senior	94	25.7
			Junior	122	33.3
Recent/Currrent Usage of WebCT			Sophomore	103	28.1
Fall 2006	238		Freshman	42	11.5
Spring 2007	163		Other	5	1.4
			Total	366	100

Qualitative Data

Qualitative data was collected in the final section of the questionnaire. In this section respondents who had used WebCT were asked to identify features that they frequently used. They also were asked to record positive and negative experiences using WebCT. Finally they were asked if they had any suggestions for improving the WebCT software.

RESULTS

We found that about 90% of students had experience with WebCT, ranging from 1 to 4 or more courses. Most students strongly predict they will use WebCT in the future. The more experience they have had, the more likely they are to choose "quite likely," or "extremely likely" to describe predicted future use (see Table 4). Regression of future use on usefulness and on ease of use

revealed an interesting difference between experienced and inexperienced students (see Tables 2 and 3). Among experienced users, both usefulness and ease of use variables were highly significant and together accounted for almost 50% of variation in expected future use. The coefficient of usefulness, at .72 was more than twice as strong as ease of use, at .33. Among inexperienced students, results were opposite. Perceived ease of use, at .45, was more than twice the coefficient of perceived usefulness, .21. However, with just 33 inexperienced students, only the perceived ease of use coefficient was significant.

Table 2: Experienced users

Regression Statistics	
Multiple R	0.694423586
R Square	0.482224117
Adjusted R Square	0.479057292
Standard Error	0.906153702
Observations	330

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	250.0682753	125.0341377	152.2736875	1.82889E-47
Residual	327	268.504452	0.821114532		
Total	329	518.5727273			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.191934608	0.343304293	-0.559080128	0.576489718
PUSE	0.722037678	0.056468299	12.78660214	1.22965E-30
PEUSE	0.330012703	0.075778455	4.354967421	1.78299E-05

Table 3: Inexperienced users

Regression Statistics	
Multiple R	0.509631275
R Square	0.259724037
Adjusted R Square	0.211964297
Standard Error	0.757508563
Observations	34

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	6.241015828	3.120507914	5.438137631	0.009453694
Residual	31	17.78839594	0.573819224		
Total	33	24.02941176			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	1.427896628	0.932073831	1.531956569	0.135675825
PUSE	0.205849948	0.201800645	1.020065859	0.315592401
PEUSE	0.450934549	0.265181196	1.700477089	0.099054171

Grouping students into age categories of under 21, 21-22, 23-35, and 46-55, did not show any marked differences in acceptance. Most students were in the first or second age group.

Table 4: Respondents who voluntarily used WebCT

Regression Statistics	
Multiple R	0.56555569
R Square	0.319853239
Adjusted R Square	0.310136856
Standard Error	0.998898254
Observations	143

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	65.69293437	32.84646719	32.91896391	1.91507E-12
Residual	140	139.691681	0.997797722		
Total	142	205.3846154			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.32328715	0.713329039	-0.453209014	0.651099885
PUSE	0.653659415	0.109091893	5.991823947	1.66718E-08
PEUSE	0.406892154	0.138834376	2.930773823	0.003949965

Table 5: Respondents who involuntarily used WebCT

Regression Statistics	
Multiple R	0.748915155
R Square	0.56087391
Adjusted R Square	0.556568752
Standard Error	0.844376432
Observations	207

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	185.7711933	92.88559663	130.2795258	3.50028E-37
Residual	204	145.4461981	0.712971559		
Total	206	331.2173913			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.003481307	0.365839652	0.009515936	0.992416796
PUSE	0.757827724	0.062763696	12.07430044	1.11639E-25
PEUSE	0.260671046	0.085780129	3.038827853	0.002685741

Most students indicated their use of WebCT was not voluntary. Students volunteering to use WebCT were more likely to choose "quite likely," or "extremely likely" to describe predicted future use (see Table 4). When separate regressions were run for those who used WebCT

voluntarily and for those who were required to use it, those required to use it were more concerned for usefulness: coefficient .76 was highly significant. The coefficient for ease of use was also highly significant at .26. For those voluntarily choosing WebCT, usefulness and ease of use were both significantly related to intended use, with coefficients of .65 and .40. Apparently if one was forced to use technology, they had better find it useful. If they are to be willing to volunteer, it had better be easy to use as well.

Dividing the data by gender, males strongly considered usefulness, with a coefficient of .67 significant at P-value=1.43E14. About 38% of variation was explained. Ease of use was at .24, and significant at P=.02. Women were also most concerned for usefulness, but the coefficient for ease of use was highly significant as well, at P=6.68E-05, and .41. So ease of use cannot be ignored.

CONCLUSIONS

We found that the experienced WebCT users were more concerned for perceived usefulness. Inexperienced users were more concerned for ease of use. This seems reasonable, perhaps inexperienced users feared the unknown effort required and were less able to imagine the potential benefits. Our confidence in this interesting result would be stronger with a larger sample of inexperienced students. As we surveyed primarily our own business majors, who are nearly all experienced after the freshman year, we plan to extend the research to more non business majors. If the results are confirmed, there are implications for encouraging use of WebCT. When approaching new users, the technology needs to be made easily accessible, and students need to be reassured that it will not be difficult to use. When the goal is to get experienced students engaged in additional use of WebCT, it is more important to stress the usefulness of this technology.

In further research, the authors will attempt to improve the survey questions. The six questions that made up each variable did not make clear distinctions. They seemed substantially redundant. Response patterns suggest students did not discriminate carefully. Usefulness, ease of use, and acceptance rates were all relatively high. The students were "low discriminators." New questions are being developed to obtain more precise feedback, with specific dimensions of usefulness based on students' qualitative responses describing how they actually use WebCT. Ease of use questions can be made more detailed as well, in terms such as time required, clarity of instructions, reliability, and accessibility. Further results will allow educators and software providers to adapt the technology and its presentation to improve acceptance and effectiveness.

The model assumes rational behavior on the part of students, when they perceive that they really have little discretion in whether they will use WebCT.

REFERENCES

References and regression output available on request from the authors.

INTRODUCING BUSINESS THROUGH STATISTICS

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ABSTRACT

This paper describes a redesign of the first-year business statistics course to serve primarily as an introduction to business while at the same time adequately covering the necessary statistical topics. It describes the kinds of examples used to introduce students to the various business disciplines, how spreadsheets are used to involve the students more thoroughly in the business environment and to reinforce the importance of effective communication, and the particular classroom vehicle used to enable more efficient use of class time.

INTRODUCTION

During the academic year 2004-05 the Management Division of Le Moyne College revised its curriculum and introduced a fourteen course common management core for all majors in the division. Up to this point there had been different first year introduction courses for various disciplines. Part of the objective for the business core was to provide a common experience that students could use to help determine the majors they wished to pursue. Individual first year courses were not consistent with this approach. One course, as an introduction to all majors in the division, was considered. However the faculty found itself already negotiating carefully over the size and make-up of the core. The division elected to try an experiment in which we used our required first statistics course as the course that would provide students with an introduction to all disciplines in management. The challenge was to conceive a shift in focus from the traditional "Statistics for Business" course to an "Introduction to Business" with statistics providing the connecting paradigm. The course was realigned as a freshmen course and boldly marketed as the course undecided students should take if they are considering a major in business!

There was, understandably, some skepticism about using statistics as the course that would introduce all students to the possibility of pursuing one of the business majors. Historically at many business schools students and alumni rank statistics lowest among their business courses [1], perceive them to have little value and to be extremely difficult [2] and identify statistics as the most difficult and least pleasant course [3]. Undaunted by this "bad press" we set out to produce a statistics based course that would be a successful introduction to business.

Our challenges were several fold. First, we had to make sure that the course provided students with an accurate representation of what it would entail to be a business major. Second, we had to make sure that the course was an attractive experience for students exploring alternatives in business. Last but not least, we had to make sure that students achieved the level of competence in statistics expected in rigorous business programs. To achieve all these objectives, a critical task was to identify a vehicle that would allow us to cover more than the usual amount of material in the same amount of time, and in a way that created a positive experience for students. In addition to our commitment to introduce students to some realistic examples from all our business majors, we also decided to use Excel spreadsheets for all our statistical analysis. This

gives us the opportunity to demonstrate for students how spreadsheet modeling can serve as a valuable tool in their future academic career and beyond. We emphasize the utility of this tool by showing students some of the many advanced features available in Excel to create spreadsheets that actually function as decision support systems. This aspect of our approach has been one of the highlights that contribute to our ability to grab student interest.

At the end of one year of implementation it appears that our efforts have been a success. We have used our approach in all the statistics sections taught by four professors. Our students are getting a consistent exposure to business, spreadsheets, and statistics. Their overall response has been most favorable. In fact our students get so caught up in the business problems and the creative uses of spreadsheets they almost fail to notice that they are actually learning statistics.

In the remainder of this proposal we will focus on three key elements of our approach. The first section will briefly describe the types of introduction to business experiences we have created to present statistical concepts. The second will describe some of the spreadsheet features we use to enhance our course delivery and keep students motivated. And finally, in the third section we will describe the particular in-class vehicle that allows us to cover so much material with great efficiency and effectiveness. The proposal will conclude with some summary outcomes from the student evaluations for the first year.

THE USE OF BUSINESS

There is certainly nothing new about using business applications in statistics classes. However in most cases the applications are primarily intended to illustrate statistical concepts. In our case we wanted the examples to give students insight within the areas of application. One difficulty faced in any freshman business course is that students lack sufficient maturity to be able to appreciate many managerial issues. Using data to explore business environments could provide first steps toward gaining understanding of complex issues. Realistic (and large data sets) give the students something tangible that they can use to begin to see the consequences of decisions. Every new section begins with a business problem and business data. Discussion of statistics evolves as necessary to address the problem at hand. In addition to initiating all discussions in a business context, our mandate in designing appropriate examples focused on attempting to convey the basic extract of each of the disciplines in business.

In finance, our applications introduce examples of risk management with an emphasis on understanding the financial implications under uncertainty and managing the associated risks. Analysis of the risk of two or more stock portfolios versus single stock portfolios serves as an introduction to understanding the role of risk in financial evaluations. Of course at the same time it serves as an ideal context for justifying variances and coefficient of variation. Valuating investments and lease options is also integral to financial calculations. For us it generates a need for expected values and statistics for random variables. Revenue management is an increasing important part of finance studies. A revenue management case allows us to focus initially on break even calculations and the use of Excel's solver to produce breakeven points in spreadsheets. In addition, our this case is based on marketing survey results and our confidence in the sample means from these surveys leads obviously to questions about confidence intervals.

Marketing applications focus on the role of marketing managers throughout the entire process from product quality to revenue management. One application investigates the consequences of promising a higher quality product to a customer. Engaging students in discussions about quality control and the benefits of reducing variance in the contexts of the shared responsibility of marketing and production personnel helps to illustrate that marketing is not merely about selling. In another example marketing survey results are used in discussions on revenue management again involving finance and marketing perspectives.

Human resource management examples focus on issues of compensation and the use (or misuse) of merit bonuses in attempts to improve productivity as well as on operation areas in the context of efficient use of personnel resources. Deming's Glass Bead Game [4] serves as a vehicle for discussing merit bonuses and quality control and eventually requires an introduction of binomial random variables. Accounting cases introduce students to financial audits and system control audits emphasizing accountants' roles in both financial and managerial issues. One common theme to all our cases is the necessity for communication between all areas of a business entity. The data for all of our examples, while realistic, was generated to illustrate specific points.

In addition to using the course as an introduction to broad disciplines we were also able to encourage to students to begin to be aware of career options. The course begins with a look at data of potential interest to students, starting salaries of for recipients of bachelor degrees and salaries for numerous business and management positions. The data is of course used to discuss means, medians, and percentiles. However much of the data comes from Department of Labor websites where students will also find descriptions of career paths, work environments, and credentials for hundreds of positions. Hence we begin with an exposure to a wide variety of careers.

DEVELOPMENT OF SPREADSHEET SKILLS

Most students come with some experience with spreadsheets. They not only have typically used them, but they are also convinced that spreadsheets are an important business tool, and one that is worth developing. Therefore the choice of spreadsheet statistical analysis allows us to emphasize the business aspect of the course more so than other standard packages. We further develop the business focus by integrating features of Excel beyond statistical tools and calculations. The use of sophisticated tools such as array functions, pivot tables, and data tables certainly impresses them and enables them to see the relevance of combining statistical analysis with spreadsheets. But even simple tools such as spinners and conditional formatting bring smiles to their faces. They begin to see spreadsheets as not only a means for analyzing data but also as a tool for effective communication.

In one exercise students create a spreadsheet (see Figure 1) that they can use to better understand confidence intervals. First they learn to simulate a sample of 100 values from a normal distribution with a given mean and given standard deviation. For this sample they calculate a confidence interval. Since the simulation is based on Excel's random number function, each recalculation creates a new sample and consequently a new confidence interval. By using Excel's Data Table function students can record the confidence intervals for 100 different samples. Next they can use the Countif function to determine the number of times the confidence intervals failed to contain the true mean. A visual image is created via a hi-lo-close graph the 100

confidence intervals. Finally students can use a spinner to change the level of confidence and see the impact on the width of the intervals as well as the number of times the true mean is missed. On the one hand, we have a tool for understanding the concept of confidence intervals. But, because the students have built the tool themselves from scratch, they are more fully vested in the exercise and more interested in seeing how it works.

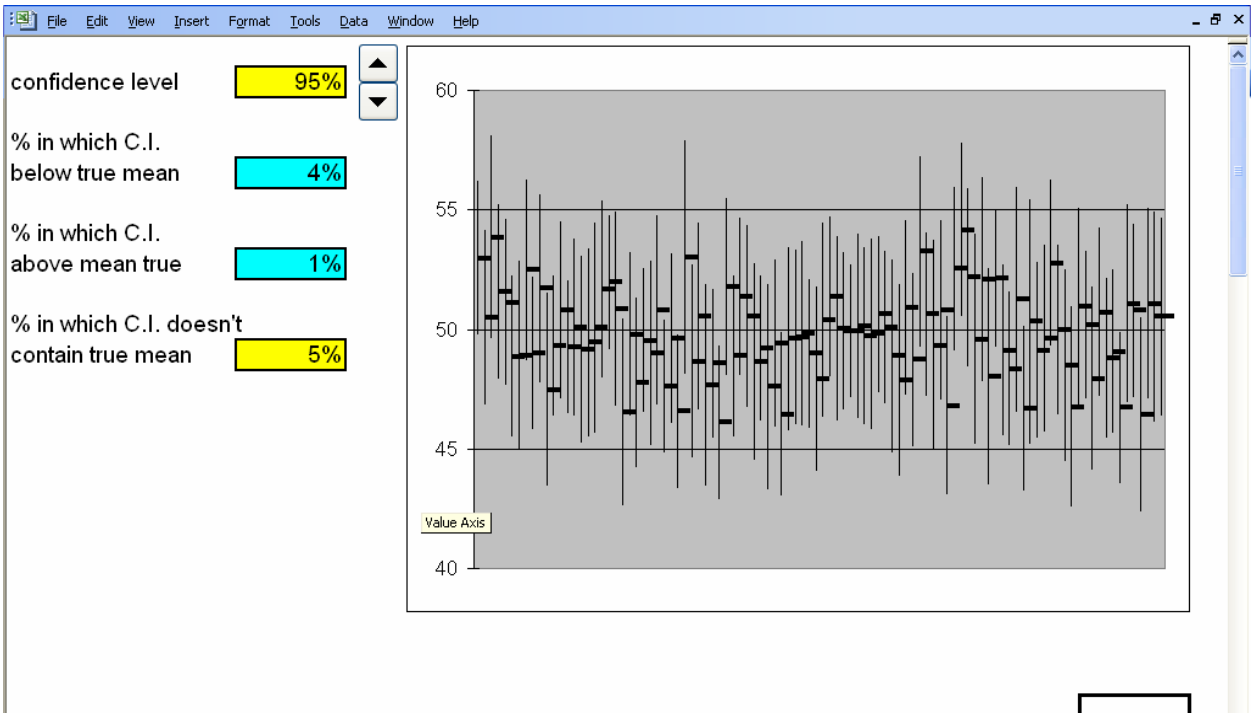

FIGURE 1. Confidence Interval Simulator

In another exercise, students develop a decision support spreadsheet model (see Figure 2) with which they can examine different staffing combinations of full and part-time employees in a customer service call center. A variety of realistic differences between full and part-time employees are incorporated within the model – including abilities, hourly pay rates and scheduling options. Assuming various normal distributions for incoming calls, the probability that the number of incoming calls will exceed the capacity of the call center, in any given hour, is determined. Using conditional formatting, these probabilities are then color highlighted whenever they exceed a specified acceptable level. The students are therefore able to quite realistically consider different staffing scenarios, the associated costs and the impacts on service capacity. They are excited when they realize that they are developing skills that they can use to create effective decision support systems and communication tools.

COURSE MATERIAL

The course covers descriptive statistics, probability theory, and confidence intervals and hypothesis testing for means, proportions, and differences in means. These are the typical topics covered in the first semester of an introductory statistics course. As previously mentioned, we wanted to provide this comprehensive coverage and achieve the objective of introducing students

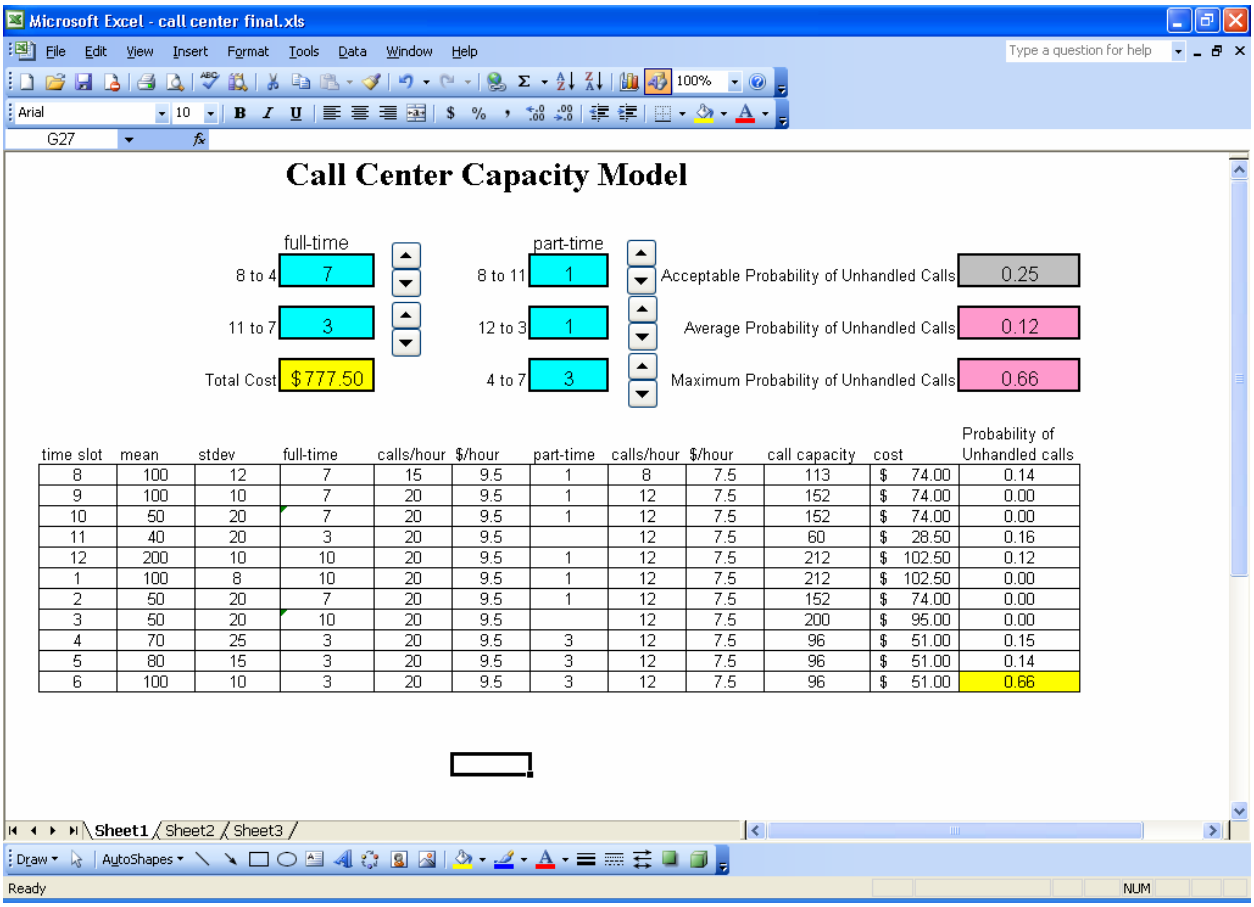

FIGURE 2. Call Center Model

to business education as well as give them advanced experience in spreadsheet modeling. A key component in our success in accomplishing all these objectives is the workbook we designed to help students record and maintain important information. The innovative structure of the workbook enables us to keep the course moving quickly and efficiently. It is, in essence, a collection of course material organized as incomplete outlines tables, graphs and text. The students use these documents to take notes as they follow the progress of the class conducted by the instructor using overhead transparencies that exactly match the pages of the workbooks. These workbooks provide an efficient and effective means of note taking for the students. So much so that, once completed, they can serve as the course text or the primary source of course information.

The structure of the workbook includes notes, spreadsheet instructions, and in-class exercises. At all times students are directly involved either in filling out their workbooks, creating spreadsheets, or practicing modeling concepts. The efficient note taking allows us to quickly cover material and the immediate reinforcement enables student to avoid the frustration common in statistics courses. In addition the process of students working simultaneously with the instructor allows us to minimize the use of confusing formulas and to focus on the concepts behind our calculations.

STUDENT REACTIONS TO THE COURSE

This approach has been very well received by the students and their comments are enthusiastic. To have college freshmen state that statistics is their favorite course is most rewarding for our instructors. The formal course evaluations have been outstanding. In the first year the course was taught by four instructors, in ten sections, with over 250 students. The average score for the overall rating of the course was 1.9, where a score of 1 is identified as "superior" and 2 is labeled "excellent". The average statistics course rating is better than the average score for the entire institution (2.1). This is additionally noteworthy since, at Le Moyne, evaluations in introductory courses tend to be worse than those in higher level courses. And it certainly is in contrast to our previously noted references that indicate that students historically rate business statistics as the worst of all business courses.

An unanticipated benefit of our approach has been consistently high evaluations for all instructors and all sections. Our instructors represented a wide variety of backgrounds. Two are senior faculty with many years of experience but who had always used different statistics software in their classes. One was a former administrator who was returning to teaching after many years absence from the classroom. The fourth was a part-time adjunct who had not previously taught statistics. One teaching evaluation question that is considered as highly indicative of the success of a class is: "if given the opportunity, would you take this instructor again?" On a scale from 1 to 5, with 1 denoting "always", the mean scores in the ten sections fell between 1.0 and 1.6, with an average of 1.27. The average for the college is 1.7! That all of our instructors were rated significantly better than the college, speaks well of both the students' and the instructor's reaction to our innovations.

The student responses surpassed many of our expectations and went a long way toward quieting concerns about introducing business with statistics. The professors' experiences indicate that the course objectives were successfully met. Judging from students' reactions, the freshmen statistics class is one of the most popular classes among first year students.

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RE-INVENTING BUSINESS EDUCATION: THE ROLE OF EXPERIENTIAL LEARNING IN THE DELIVERY OF A FOUNDATION BUSINESS COURSE

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ABSTRACT

The delivery of introductory business courses needs to provide a solid conceptual foundation and inspire students to consider the exciting aspects of a career in business. The role of business education, in early coursework, often focuses on the lecture-based, "chalk and talk" delivery methodology. The competitive and dynamic nature of business organizations requires students to understand business in a multi-disciplinary context. The integration of application-oriented projects in an active learning environment can increase the knowledge and retention the business concepts.

INTRODUCTION

In an article from Fortune Magazine's February Sixth edition (Colvin, 2006), it was stated that the most valued traits in managers include the ability to deliver explosive results, a feat accomplished differently than five or ten years ago. The most important skills are the capacity to motivate, communicate, and engage – traits of which contemporary managers fall short. However, as we reviewed our own courses in business, specifically the first course, Introduction to Business (BUS101), we realized that our curriculum failed to provide many of the substantive skills today's businesses require. Our format did little to force teams to think, to be innovative, and to move beyond their comfort zones. Furthermore as business enterprises de-emphasize functional structures (Cannon, Klein, Koste, & Magal, 2004) our continued functional approach to the curriculum, as well as the way we taught, was fast becoming obsolete. Finally, retention between freshman and sophomore year was declining, in part because our "chalk and talk" approach did not engage the students, and failed to tap into their creativity and desire to learn. A change was needed, and quickly. Our immediate goal was to ensure that upon completion of the first course in business, each student had the ability to communicate effectively, think and act decisively, and lead in any position pursued – in essence deliver the elusive "explosive" results.

BACKGROUND

In order to teach students these skills and develop problem solving strategies, it would be necessary to design a curriculum that provided the opportunity to engage students in collaborative decision making. Action learning – focusing students on a real time work problem that forces them to rely on each other to solve problems and tackle unfamiliar terrain – provided an approach for achieving such an outcome, (Raelin, 2006; Revans, 1982). According to (Raelin, 2000), there are three common principles that underscore action learning: 1). that learning be acquired in the midst of action and dedicated to the task at hand; 2). that knowledge creation and utilization be seen as collective activities wherein learning can become everyone's job; and 3). that its users demonstrate a learning to learn aptitude which frees them to question the underlying assumptions of practice (Raelin, 2006).

As we explored our options to transition the course to a more action learning environment, we realized we wanted to also include elements that are at the heart of experiential learning, and result in heightened self efficacy – a trait which enhances an individual's sense of ability and personal achievement. Therefore, it was necessary to create an approach that provided concrete knowledge, challenged the students to think beyond what they themselves thought capable, and offered a personal experience that would ultimately enhance their self efficacy.

Based on this initial research, we decided to 1) offer theoretical material that reflected a more integrative approach to business; 2) require students, as a team, to develop an original business plan; and, 3) generate enthusiasm through participation in course competitions. Ultimately, we envisioned that these outcomes would result in enhancing students' confidence in their choice of degree and heightening their knowledge and/or interest in business.

Purpose of the Study

The purpose of our study was to determine if the changes to the course resulted in heightened student confidence in degree selection after completing BUS101. Additionally, we needed to assess whether their level of business knowledge increased through the new course pedagogy.

RESEARCH METHODOLOGY

An empirical methodology was implemented to fulfill the objectives of this research study. The methodology consisted of the development of research hypotheses, survey design, survey administration and statistical analysis.

Hypotheses

Several research hypotheses were developed in order to frame the development of the survey instrument and the statistical analysis. The framework of the hypotheses (shown in parentheses) supports the objective of the research through two categories:

a) Comparison of the individual preferences before and after the course completion for the entire population over two semesters (1a-3a)
b) Comparison of the individual preferences before and after the course completion for the entire population over two semesters for business degree students (1b-3b)
c) Comparison of the individual preferences before and after the course completion for the entire population over two semesters for liberal arts degree students (1c-3c)

Each of the hypotheses created a foundation for the basis of the statistical analysis which will provide insight on the individual students' preferences based on the intervention of the course pedagogy and deliverables. The results of the statistical analysis will determine the magnitude of perception change associated with the completion of the course. A listing of the null hypotheses is outlined in Table 1*.

Survey Design

The survey instrument was implemented in a web-based environment. The instrument was designed to minimize measurement error by separating the survey into four components:

1. Initial degree selection and certainty
2. Preferences prior to the beginning of the semester
3. Preferences after the completion of the course
4. Demographic data relating to the respondent

Several survey questions were designed in pairs to measure perceptions before and after completion of the course. The scales of the paired questions were designed to be consistent in order to accurately measure the differences between the initial and after-completion of the course responses.

Survey Administration

In an effort to compile accurate results and gain an appropriate response rate, the population used for this research included all sections of BUS101 over two semesters. Since BUS101 is a required course for first year students across all degrees and majors, this population would provide the basis to collect responses from a broad and inclusive group of students and majors. In addition, the survey population also included multiple professors and semesters to provide enough variability in the delivery and registration time period.

Each professor was asked to provide a data file containing three fields: email address, first name and section of the student in their section(s). The individual data files were merged to create one file. Three email letters were created: 1) introduce the survey and request their participation, 2) letter with an embedded URL to access the survey instrument and 3) a follow-up reminder. Each of the two survey implementations (January and September 2006) followed the same email procedures.

Each survey administration was conducted after the completion of the semester. The timing methodology was a deliberate decision to provide some "distance" between the end of the semester and the survey administration. This would allow the respondent to conclude their perceptions on their experience with BUS101 by a) eliminating any measurement error associated with the stress of the final business plan submission and final exams and b) provide some independent reflection after the semester was completed.

Statistical Analysis

Each respondent answered three questions which were related in measurement within a context of two different timeframes. Therefore, the respondent's data was analyzed comparing the paired difference between the perceptions for each question. To complete the statistical analysis associated with these questions, a Wilcoxon Signed-Rank Test was used. The Wilcoxon Signed-Rank test, a non-parametric methodology, calculated the ranks of the absolute values using two related variables to test the hypothesis as to whether the two variables have the same distribution. This statistical test provided information about the magnitude of differences within variable pairs and assigned more weight to the variables calculating large differences than to those having small differences. The test statistic was based on the ranks of the absolute values of the differences between the two variables. The significance value ($p<.05$) of each test was used to evaluate the null hypotheses.

Semester	Total Students	Number of Sections	Total Responses	Response Rate
Fall 2005	352	11	240	68%
Spring 2006	328	11	178	54%
Total	680	22	418	61%

Table 2 – Summary of Survey Response

Frequency Distribution of Responses

A frequency analysis was compiled to determine the number of responses in relation to two classification criteria: initial degree selection and gender. The results of the frequency distribution are

shown in Tables 3* and 4*. Almost 70% of the students responding to the survey selected business administration as their initial degree of choice. This high percentage is not surprising based on the University's original founding as a specialty business school. The frequency distribution by gender is more balanced with 56% vs. 44% (male/female) ratio.

Wilcoxon Signed-Rank Test for Entire Group

The non-parametric Wilcoxon Signed-Rank statistical test was completed to determine whether the paired-question hypotheses (1-3) should be accepted or rejected. Table 5 includes the grand means associated with the paired-questions (initial vs. after) as well as the total number of responses received (n). From the results, 89 respondents did not answer the certainty of their degree selection if they were undecided on a major selection. Therefore, the Wilcoxon test excludes those responses from its results.

The results of the Wilcoxon Signed-Rank statistical analysis are shown in Table 5a*. The sign (positive, negative or tie) is based on the values of the paired-question responses. The statistical test calculates the rank values as negative (after < initial), positive (after > initial) and tie (after = initial) for each observation. These values are used to project the result of the paired question based on the intervention of a stimulus, in this case the completion of the course. The asymptotic significance value (p-value) is calculated for each paired-question analysis as shown in Table 5b.

	After – Initial Value					
Question	Negative Ranks	Positive Ranks	Ties	Total	Asymp Sig.	
Degree Certainty	33	81	215	329	0.000	***
Business Interest	38	53	327	418	0.141	ns
Business Knowledge	240	29	149	418	0.000	***

Table 5b – Wilcoxon Signed Rank-Test (*** = p<.001)

The means of the paired questions must be evaluated (based on the instrument scale) in relation to the p-value provided by the rank test. Based on the instrument scale, a lower mean "after course" value will translate into more positive results, either more strongly agree or increased level of business knowledge.

Based on the results of the statistical analysis, the degree certainty and business knowledge question pairs are highly significant. The results assert that students are less certain on their degree choice after the course was completed (p<.001). The analysis found that there were no significant differences found relating to the question on business interest. In the third paired question, the results of the analysis calculated that the students believed that their business knowledge is greater after completing the course.

Wilcoxon Signed-Rank Test by Individual Degree Selection

In order to explore the effect of the course in more depth, two additional Wilcoxon statistical analyses were completed. The analyses were completed by segmenting the student's initial degree selection into two categories (business and liberal arts). The results of the analyses are illustrated in Tables 6a* and 6b (business students) as well as 7a* and 7b (liberal arts students) shown below.

Question	After – Initial Value: Negative Ranks	Positive Ranks	Ties	Total	Asymp Sig.	
Degree Certainty	30	67	192	289	0.000	***
Business Interest	20	39	230	289	0.015	*
Business Knowledge	162	22	105	289	0.000	***

Table 6b – Wilcoxon Signed Rank-Test for Business Students (* = p<.05, *** = p<.001)

Question	After – Initial Value: Negative Ranks	Positive Ranks	Ties	Total	Asymp Sig.	
Degree Certainty	3	14	23	40	0.006	**
Business Interest	9	4	27	40	0.265	ns
Business Knowledge	26	2	12	40	0.000	***

Table 7b – Wilcoxon Signed Rank-Test for Liberal Arts Students (** = p<.01, *** = p<.001)

With the exception of one paired-question analysis, each of the remaining five tests showed significant differences between the ranked values. The results illustrate an increased certainty in their initial degree selection. However, their business knowledge decreased after completing the course. The paired-question associated with the business interest calculated significant differences only for business degree students, showing increased business interest.

FINDINGS AND CONCLUSIONS

As stated previously, the purpose of this research was to determine whether the course re-design provided a positive effect on the student's certainty of degree choice, business interest and business knowledge. The findings should provide a "yardstick" on the level of success associated with the intervention of the course re-design and delivery.

The results of the tests clearly indicate that students are less certain about the selection of their initial degree choice. Each of the three tests calculated the same results. It was disappointing to learn that business students are less certain about their original selection of their business degree after completing the course. While their responses remain between strongly and somewhat agree, the after course completion mean of their responses was lower (1.65 vs. 1.49 initially).

It is interesting to note that liberal arts students are also less certain about their degree selection after the completion of the course. The fact that there are no significant differences between the means (initial vs. after) conclude that students feel the same about their interest in pursuing a business degree. However, the response of this question by liberal arts students also indicate a movement to "agree somewhat" to an interest in a business degree after the course was completed (2.45 vs. 2.63 initially).

Coincidentally, the interest in pursuing a business degree provided similar results. The results assert that business students are less interested in pursuing a business degree after completing BUS101. While the change in their perceptions after the course completed is slight (1.33 vs. 1.25 initially), it does indicate that students are reflective about the course experience. Additionally, the business degree group was the only statistical test that provided a significant p-value. While disappointing on its face value, the mean

value still indicates responses closer to "strongly agree" even considering the after course completion response.

The explanation of this result could indicate that students' perceptions drawn from their high school education and teenage experiences may not have provided an accurate representation of business concepts and level of difficulty. The media attention associated with the examples of "spectacular" business successes identified by teenagers such as Google, MySpace and eBay may provide an unrealistic sense of the effort and knowledge that are required to start and operate a business. This level of information is not evident in the "sound-bites" often provided by the mass media. Successful entrepreneurial business examples such as these often glamorize the result rather than the effort and business wisdom needed.

The outcomes associated with the level of knowledge of business concepts provided different results from the previous two paired questions. It is clear that students believe that their business knowledge increased significantly based on the rank tests and the means comparison. The results of the entire group, as well as the individual degree analysis, provide clear evidence that the course pedagogy and structure significantly expanded their business knowledge. It is interesting to note that liberal arts students, while not initially interested in pursuing a business degree, also declared their increased knowledge after competing BUS101.

The results of the research provide valuable empirical insight on the intervention of course re-design. However, while not as directly conclusive, anecdotal perceptions from students can substantiate the empirical evidence as well as enlighten the results of the course with non-quantitative commentary. In December 2005, students were asked to provide comments on their experience with the course. A sample of their comments is provided in Table 8*.

The comments underscore the need for the various business concepts and methodologies to be reinforced and developed through the use of experiential learning. It is clear that the application of challenging projects such as the elevator pitch and marketing competitions as well as the business plan report and presentation, provide a solid foundation of knowledge retention. This important component of higher education was reinforced by a conversation between a senior marketing professor and a BUS101 professor. The marketing professor conveyed comments received from students registered for the Introduction to Marketing (MKT201) course, a required course of all students elected after BUS101. Feedback from the students in MKT201 suggested that many of the marketing concepts were a duplication of those discussed in BUS101. The marketing professor did not believe that this was negative, but an affirmation that a) students were retaining what they learned in the introductory course and b) may require some fine-tuning of the delivery of MKT101.

This research study clearly indicates the importance of experiential learning as a complement to a lecture-based, survey introductory business course. The result of the research clearly affirms the expansion of business knowledge after completing the course. While degree certainty and business degree interest appear to have been adversely effected, the cause could be consequence of a lack of experience and realistic knowledge relating to business planning and entrepreneurial topics.

REFERENCES

Tables (identified with *) and references will be provided by contacting authors.

AN EXPERIENTIAL LEARNING SIMULATION: ORGANIZATIONAL PROCESSES AND OUTCOMES IN STRATEGIC NEGOTIATION

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ABSTRACT

This action research paper submission describes a novel experiential learning exercise in peer negotiation, introducing students to organizational decision making, strategy, and creative conflict management, addressing the importance of management education as a vehicle for successful professional development, cultivating student core competencies in the science of negotiation, decision making and conflict resolution, inspiring motivation towards learning tools and techniques, honing fundamental skills required for business management best practices.

Keywords: Strategic Negotiation, Organizational Decision Making

INTRODUCTION

Historically, the field of Management, although devoted to progress and change, unfortunately, has not successfully answered an important question of how managers and organizations truly learn and acquire core competencies, yielding business management best practices. Thus, this manuscript identifies a novel experiential learning simulation in peer negotiation and its' pedagogy, that may be used to help educate and develop business students into industry professionals with needed core competencies in strategy, negotiation and creative conflict management.

Importantly, today's business schools are required to change with the times and seek the best balance between theory and practice. Because faculty members are a critical resource in any academic institution, business faculty must continually develop new knowledge and ideas, and transmit and interpret knowledge through teaching and learning processes with students and professionals.

The study of business management and its' practice takes place in a professional context that requires an interdisciplinary and applied orientation. And, while intellectual rigor must be critical, professional relevance is equally important. Business faculty need to have their feet planted firmly in rigorous theory, as well as in applied business issues. Hence, business schools need to continually move in the direction of problem or issue oriented teaching, the potential for professional application, and a multidisciplinary approach to teaching business management best practices.

Accordingly, novel experiential learning simulations provide the hands on portable skills building that assist students' professional development, while cultivating and honing managerial core competencies within an educational setting.

LEARNING AND APPLIED PRACTICE

Undoubtedly, developmental and successful learning involves creating situations in and out of the classroom where students are encouraged and required to read frequently, think critically, speak fluidly and listen intently. What successful learning amounts to is getting students to think about the subject matter, and if they are actively thinking about it, they are more likely to learn it. Perhaps, then it is best said, that the essence of student learning is two fold; providing innovative instruction and creative experiential learning exercises which challenge students ability to think critically by integrating experiences that bring students closer to real world business management practices.

Active learning, then, includes movements away from the lecture format and should consist of group work using simulations, problem-based learning, and other approaches that truly stress student engagement. The variety of approaches possible to achieve this end, are crucial, as teaching is individualistic in its nature. Active learning is something we want to promote and consistently develop within our students.

Content and Transferability

Traditionally, classroom teaching of coursework in business management is comprised of several pedagogical approaches that integrate organizational theory with real world business application(s). Towards this end, the use and combination of textbook and case reading(s), project assignments and other classroom activities to facilitate integration of prescribed subject matter and students' professional work experiences is paramount.

Students need to be simultaneously required to prepare an in-class oral presentation that demonstrates their mastery of essential reading materials while integrating their experience in the business arena. And, in addition to weekly reading assignments, experiential learning exercises that focus on managerial core competencies using self-assessment and managerial skills-building exercises are imperative. Assessment tools that can be used are self-report questionnaires that identify students' managerial decision making styles, personality type(s), occupational interest inventories, conflict management styles, leadership styles and simulations identifying core competencies in collaborative negotiation, strategy and creative conflict resolution. Accordingly, in treating the subject of "styles" as part of a negotiation curriculum, for example, teachers may find that using self report questionnaires and/or objective assessments are very useful tools to help students gain perspective on the topic at hand.

In contrast, most courses in negotiation focus typically on attention and interactions among parties involved in actual negotiations, only. Such courses usually tend to isolate the negotiation process from the social context within which it is embedded, or assume students need only know about one small piece of the social context, such as the business world or the legal system.
However, a novel peer negotiation simulation encourages students to step back from the negotiation process per se, and think more broadly about the social context within which they are operating.

To this end, it is vital to have students think critically about how the larger social problem or

social conflict is affecting the negotiation process. Simply stated, negotiation is a process for managing or resolving conflict that emerges within a social context. And, the context or setting of the conflict carries within it certain norms, rules, and expectations about how the process will be managed. Therefore, it is imperative that students simultaneously learn how to self monitor, self regulate and self assess, while also observing their peers when engaging in negotiation.

In my classroom learning environment, prior to administering any experiential learning simulation, students must complete and then review a compilation of numerous self assessment questionnaires and their corresponding results. Once completed students are encouraged to share findings of their self-assessment data, highlighting areas of strengths and limitations, honing competencies to effectively evaluate themselves, while respecting others differences, enhancing the classroom learning community. Correspondingly, in preparation for pairing students for experiential learning simulations, based on student self assessment data, students can then be grouped with peers of similar and diverse profiles to enhance their performance effectiveness.

Through the use of an experiential learning exercise in peer negotiation, students learn that no ideal solutions or perfect answers exist for any and all business scenarios. Rather, students are asked to learn how to critically think through the issues, problems, facts, and other information presented in the simulation. Students must learn to think strategically, formulating plausible assumptions about an imaginary scenario, listing problems in order of priority, designing an action plan, outlining constraints that limit success, and then selecting the most successful intervention to resolve the organizational problem.

In most organizations, and as depicted by experiential learning exercises, decisions are generally made with incomplete information and some uncertainty. As a result, critical thinking is extensively stressed and is called upon ubiquitously throughout much of the requirements in class. Without doubt, experiential learning exercises help shape and form students' managerial core competencies; comprising interrelated skills and knowledge bases that enable students to bring added value to areas of responsibility. The use of experiential learning exercises enables students to practice and hone core managerial competencies such as risk taking and visioning, mobilizing change and innovation, learning & applying ethical standards, benchmarking, decision making, conflict management, managing effective communication and managing oneself.

Contemporary Business Issues Integrated Into Classroom Dialogue(s)

As stated above, business management classes need to be driven with the integration of theory and applied real world business practices, incorporating both textbook reading(s), experiential skills building exercises, and self assessment tools. These inform students about their managerial strengths and limitations, affording them an opportunity to design a developmental action plan of personal change throughout the semester.

The enclosed peer negotiation experiential learning exercise, are individual and group based, focusing on each student's capabilities in managerial decision making, conflict management, negotiation, oral and nonverbal communication, formulation, and interpretation of case study data. Armed with essential theories and concepts derived from textbooks and lectures, students

undergo an experiential negotiation exercise that facilitates their involvement of current practices and trends in business, as an opportunity to relate prevalent issues to learned skills.

Moreover, students must be required and encouraged to integrate textbook theory with ethical principles, codes of ethical conduct, and ethical practices in their analysis and applied understanding of strategic negotiation. Both textbook readings as well as assigned case studies incorporate real world examples of well-known companies who have managed ethical issues while deftly succeeding in strategic negotiations, demonstrating mindful ethical business practices and critical dilemmas in their respective industry, past and present.

While participating in small groups, students are asked to focus on group processes and outcomes. Mutual respect, brainstorming, alternative perspectives, and power of diversity are highlighted to inform students about their own perceptual lenses, attitudes and behaviors. While analyzing real world cases about strategic change and negotiation, students are also continuously encouraged to address topics such as ethical practices, globalization, cross-cultural management, technological advances in business practices, innovation and creative problem solving.

Experiential Learning Simulation: An Introduction to Strategic Negotiation

Enclosed in appendix A, is an example of a novel classroom simulation, in peer negotiation, and experiential decision making, designed and implemented each semester in business management classes. Students are placed in groups of two, or learning teams, and given limited data describing a company and its requirements. During this assignment, all students are deemed "honorary management consulting negotiators" from their respective 'industries', and each student represents two companies under negotiation. Using effective decision making skills and ethical communication between one another, the student is required to enter into a "verbal contract" with the other party, preferably arriving at the most successful, cost effective outcome for their company.

Moreover, students' are not simply asked to attend to who "wins" the negotiation, but, rather how their negotiation occurred. After the negotiation has come to a resolution, students are asked to do an after action report. Students are required to examine the content and process, as to how successful negotiation happens and with what strategies, techniques and communication tools. The evaluation of the negotiating process and its outcomes, become a critical learning tool for students, through the exploration of an alternative towards mutual consent.

Negotiation is the science of securing agreements between two or more interdependent parties. The central issues of the business management courses taught, deals with the understanding of attitudes and behaviors of individuals, groups and organizations in the context of competitive situations. A negotiation simulation, (depicted in Appendix A) helps students understand and think about the nature of negotiation and the impact of decision making. Moreover, the objective of this classroom exercise is paramount because many of the important phenomena in negotiation, such as interests, goals and cooperation, are ambiguous, and often do NOT have right answers or a "one size fits all" solution set.

Thus, as an instructor, we cannot teach a set of formulae that will always maximize profit.

Rather, we must teach students how to manage conflict, make informed decisions, negotiate meaning between others, cultivate self-awareness, and develop strategies of how to deal with ambiguity, and how to utilize problem-solving strategies to reduce it. This negotiation simulation provides students with an experience in the negotiation process, including learning how to evaluate costs and benefits of alternative actions, improving student analytical abilities in understanding behavior of individuals and groups, cultivating new confidence in negotiating as an effective means for resolving conflict in organizations, and instigating how to effectively manage the negotiating process and corresponding outcomes in today's business practices.

Students often approach this peer negotiation simulation with enthusiasm, as its' reputation among students inspires students to want to "win" and "compete" with their peers, and it is also a graded simulation. Consequently, pairs of students are chosen based on profile data derived from student self assessment reports. Students are paired with their "complement", in an attempt to match student skills, abilities, strengths and limitations, creating a classroom learning community that is challenging, competitive and innovative, mimicking real world business environments.

In conclusion, teaching enlightens us by fostering personal growth and professional development. And, while there is no one size fits all approach to educating future business managers, for any business school to be truly successful, it must find its own level by engaging all its stakeholders. In sum, teaching and learning are undoubtedly social arts necessarily involving relationships between people.

The success of the teacher in the practice of this ancient art depends on the ability to possess a unique quality. It is an attitude of mind that enables an instructor to make the relationship between the teacher and his/her students a reciprocal one. In doing so, we recognize that not all the learning should be done by our students and not all the teaching should be done by the instructor.

In classroom teaching, creativity and innovation abound. Experiential learning vehicles are essential. And, experimentation is the word of day, as teachers as well as students are equally creative researchers of the classroom scene. The classroom becomes a learning community with shared goals, values and mutual responsibilities dedicated to collective learning and personal development. The practice of teaching offers opportunities for systematic inquiry and rigorous reasoning about substantive issues. Academic plans, course syllabi, and classroom processes become vehicles to truly express creativity and innovation.

In closing, creativity is required of any instructor. In the process of planning for a discussion, which utilizes supplementary materials in classroom exercises, such as in this negotiation simulation, shown in Appendix A, one's understanding of what remains to be discovered about the substantive issues raised in class, is really the "true lesson". Teaching enables a forum where colleagues and students of different disciplines use a variety of pedagogical approaches, discuss common challenges, and collaborate on providing solutions. Working with eager students affirms our faith in the worth of teaching as a creative tool of instruction, and its tremendous contributive potential to shaping the professional lives of future business and industry leaders.

References available upon request from Mary Elizabeth Moran

APPENDIX A

Strategic Negotiation Learning Simulation

SERVICE CONTRACT		SERVICE DELIVERY DATE			Price
Seller's Cost Savings Table					
Number	Cost Savings	Date	Cost Savings	Level	Cost Savings
1	$1200	March 1	0	A	$2000
2	$1050	March 8	$100	B	$1750
3	$900	March 15	$200	C	$1500
4	$750	March 22	$300	D	$1250
5	$600	March 29	$400	E	$1000
6	$450	April 6	$500	F	$750
7	$300	April 13	$600	G	$500
8	0	April 20	$700	H	0

SERVICE CONTRACT		SERVICE DELIVERY DATE			Price
Buyer's Cost Savings Table					
Number	Cost Savings	Date	Cost Savings	Level	Cost Savings
1	0	March 1	$1200	A	0
2	$100	March 8	$1050	B	$250
3	$200	March 15	$900	C	$500
4	$300	March 22	$750	D	$750
5	$400	March 29	$600	E	$1000
6	$500	April 6	$450	F	$1250
7	$600	April 13	$300	G	$1500
8	$700	April 20	0	H	$2000

TEACHING OPERATIONS RESEARCH AND STATISTICAL METHODOLOGIES USING REALITY TELEVISION AS A BACKDROP FOR ENCOURAGING STUDENT GROWTH AND LEARNING

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ABSTRACT

This paper looks to explore using a new innovative approach to teaching student's operations research and statistical methodologies by using examples from something that has become popular and well known among students, "reality television." Given the fact that reality shows like Survivor, which has been on for nine seasons, American idol, which has been on for five seasons, the Apprentice, which has been on for five seasons, and the Amazing Race, which has been on for nine seasons, shows their extreme popularity. Due to this popularity, it makes sense to use them as a data set for teaching quantitative methods to our students. What makes these shows so popular is the unknown about who is going to win and how are they going to succeed. Is it their strategy to play fair, nice, or ruthless? Is it their charm, good looks or wit that causes them to be successful? What exactly makes the winners of these shows, "winners?"

We examine these types of questions using operations research and statistical methods and techniques. The one specific method explored here is Correlation Analysis. A fictitious data set was created to explore how they would be used to teach this specific procedure. The model shows how this technique may or may not be useful in answering the questions at hand. What is important is to encourage student growth and learning using data that interest them. Once they see how the methodologies are useful in fun exercises, they can then apply them in business scenarios.

TEACHING TODAY'S STUDENTS

Today the students in our undergraduate classes are very different from when we were students. Sometimes referred to as "digital natives", today's students prefer games to serious school work, they prefer graphics rather than text, and they like to parallel process and multi-task. (1). These young adults grew up spending time watching reality television shows such as Survivor, Apprentice and Project Runway as well as playing fast-paced video games, alone and in groups. Our students have grown up in a media-saturated environment, spending an average of nearly 6.5 hours a day with media with television being the dominant media (2).

When asked how to improve their educational experience, many students expressed interest in making learning more fun and reduce boredom at school. There is a generation gap between professors and today's students. Math was often cited specifically as a subject that might benefit from the use of games (3).

As these students enter college, we must look at ways that this active learning paradigm can be continued to make science, technology, engineering and mathematics (STEM) lessons fun and engaging.(4) As in secondary schools, college students often lack engagement and motivation, prerequisites for learning. They are engaged outside the classroom, with a multitude of activities. Inside the classroom, it is necessary to incorporate interest and activity into the lessons. (5).

Our field is teaching quantitative skills to business and information technology students. Classes include "Applied Business Problem Solving" and "Business Statistics".

CORRELATION COEFFICIENT

Traditionally, students would learn how to use the correlation coefficient in conjunction with Regression Analysis. A least square measure criterion that seeks to minimize the sum of the square of the differences between observed data and the estimated values. (6). This same method could be used if we wanted to try and predict, based on past data, if someone would be successful on a certain "reality" television show or not. In the future, this will also be considered. However, in this study, we limited our analysis to looking at the correlation coefficient. This is a measure of how well two specific dependent variables correlate together, either perfectly negative or positive, or somewhere in between. In the past, students would have to really work through a series of math steps to finally arrive at what the correlation coefficient was. This was a timely exercise that we still use to show how we technically come up with the measure, however, now with the power of computers they simply need to insert a function (CORR) and identify the arrays of data they wish to analyze in Excel.

As seen in table 1, sixteen candidates were created and their sex, age and the number of weeks they lasted on the show Survivor were entered. For example, contestant 1 is a 23 year old male who lasted on the show for twelve weeks and contestant 12 is a 40 year old female who lasted on the show for five weeks. Then the function CORR was used to determine if there was indeed any correlation between, 1) their age and the number of weeks they lasted on the show and, 2) their sex and the number weeks they lasted on the show. The results of the correlation analysis are in table 2. As indicated there is a

TABLE 1: SAMPLE SURVIVOR CONTESTANT INFORMATION

Survivor Sample Contestant Information

	Sex	Age	How many weeks a Contestant Lasted on the Island
Contestant 1	1	23	12
Contestant 2	1	23	6
Contestant 3	2	24	16
Contestant 4	2	25	11
Contestant 5	2	25	7
Contestant 6	1	27	9
Contestant 7	1	27	15
Contestant 8	1	27	13
Contestant 9	2	28	10
Contestant 10	2	34	14
Contestant 11	1	38	2
Contestant 12	2	40	5
Contestant 13	2	43	8
Contestant 14	2	46	3
Contestant 15	1	52	4
Contestant 16	1	67	1

Note: (Sex was coded 1=M and 2=F)

TABLE 2: CORRELATION RESULTS AND FORMULAS

-0.701574553
Correlation
Formula =CORREL(C4:C19,D4:D19)

Correlation Between Age and the Number of weeks you lasted on the Island

0.162697843
Correlation
Formula =CORREL(B4:B19,D4:D19)

Correlation Between Sex and the Number of weeks you lasted on the Island

The results indicate that there is a negative correlation of .7016 between a person's age and the number of weeks they stay on the show. This shows that the higher your age is, the less likely it is your time on the island will last as long as younger people.

It is a fairly strong correlation, the interpretation, since it is a negative one, is that higher values of age correlate with lower values of number of weeks a person stays on the island. The results also indicate that a person's sex and the number of weeks they last on the island is not that strong a correlation, only .1627. If we were to use the associated regression analysis with this data, we would say that age is a good predictor of the number of weeks a person lasts on the island, but a person's sex is not.

In the future, other variables will be explored, as well as other methodologies. Past data will also be gathered to see if models can be used for predictive purposes.

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ENHANCING THE BUSINESS CLASSROOM WITH WEBINARS

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ABSTRACT

As instructors, we are constantly looking for ways to enhance the classroom experience. Examples include video clips, simulations, and guest speakers. Many current textbooks offer online resources through textbook websites where students can watch relevant video clips on their own time, link to trade and popular journals, and perform interactive exercises and clips. In addition, many texts have prepackaged PowerPoint slides which instructors can use or modify for use in their classrooms. And, of course, there are extensive resources available on the Internet.

BACKGROUND

As business instructors, we are also on the lookout for the most current information available to be sure our students are prepared for a rapidly changing world. One relatively new way of getting the most up-to-date information available is through Web-based seminars, or "webinars". Webinar topics range from a software vendor promoting new features to their software, consulting companies demonstrating their expertise in a current topic, a live talk by a well known person, to concurrently presenting a web version of an entire trade or academic conference. These Internet-based programs are typically scheduled for "live" delivery. Interested participants sign up and test the connection to be sure everything works well. The presentation itself is typically at PowerPoint presentation coordinated with a live voice-over. There may also be a live video feed available. Participants, sometimes several hundred or more, will usually have some time for questions – either audio through the Internet or through a telephone line. Other ways the participants may be able to participate are through instant messaging, email, or polling where the presenter can ask participants to answer a few multiple choice questions and the results are instantly tabulated and fed back to the group. Alternatively, if the live presentation is not at a convenient time, the presentation is usually archived on a website for review at anytime – without the interactive components.

The authors became intrigued by the rapidly growing volume and wide-ranging business topics now available through webinars. One can find webinars about almost any business topic – how to do a marketing plan, ERP software for insurance companies, designing efficient data warehouses, how to be a better leader, the outsourcing backlash, etc. And, they are current. While webinars are not always fancy and polished, they often provide industry experts speaking and answering questions today about issues of importance to business with up-to-the-minute information.

In order to explore the effectiveness of webinars as a teaching tool, the authors – who teach at different universities -- each constructed an assignment for one class using webinars. This paper describes the assignments and analyzes the effectiveness of using webinars based on survey responses collected from the students.

THE CLASSROOM EXERCISE

The coauthors each conducted a survey in their respective classrooms, one in an MBA core class – Management Information Systems, the other in an undergraduate core class – also Management Information Systems. For both classes, the students were encouraged to attend the webinar live so they could benefit from the interactive components. Frequently, the students were not able to fit the live event into their schedules so those students viewed them in "lecture format". Also, for both classes, we restricted our classes to viewing free webinars. Although many webinars were free, some of the perceived best ones, had a fee attached. Finally, as described above, the media used varied from webinar to webinar. Most webinars attended by the students were presenters using PowerPoint along with audio. None of our trials used video feeds. The questionnaire was conducted anonymously after the assignment was completed. The results and implications follow.

Undergraduate class

In the undergraduate class, students were to choose a webinar from a pre-specified list. They were to view it as a homework assignment, and report back the results to the class, through a 4 to 5 slide PowerPoint summary. Each student chose a separate webinar to report on.

The first three questions gathered demographics. The results indicated a diverse response group (30% over 25, 54% male, and all concentrations represented.) The following six questions were 5 point Likert scales relating to the assignment. These results are summarized below in Table 1.

Table 1
Perceptions of Webinar Assignment: Undergraduates
[n=35]

Question	*Percent of respondents replying excellent or very good*
How accessible was the webinar?	74%
How was the quality of the audio?	70%
Knowledge of speaker	94%
Clarity of the presentation	86%
How well your interest was kept	55% very well or well
Ease of following webinar	77% very easy or easy
Overall rating of webinar watched	74% excellent or very good

These initial results were very positive, especially coming from undergraduates. In terms of the technical aspects -- accessibility, audio, clarity of presentation -- the webinars received very high marks. This indicates that if the assignment is deemed of academic value, the use of the Internet as the medium of presentation will not pose a problem. PowerPoint presentations with synchronized audio feeds are stable and dependable Internet features today. Secondly, the students were almost unanimous in their feelings that the speakers were qualified. Ninety-four percent -- all but 2 respondents -- felt the speakers knew what they were talking about.

When asked about their interest in the subject manner, the assignment did not fair as well. A bare majority [55%] indicated that the webinar, which were roughly an hour in length, kept their interest during the entire presentation. Given the quality of the speakers and the technical aspects of the assignment, in the future, the instructors should try to match students with topics of interest to them.

A series of four open-ended questions were then asked. In some regards, these responses were of the greatest value. Representative comments are given below in Table 2.

Table 2
Open Ended Questions related to Webinars: Undergraduates

Question	*Representative Responses*
Q1: Did you like the webinar assignment?	▪ It was a new way of learning from others ▪ I was OK. If the subject was interesting enough, you could really learn a lot ▪ It was OK…It's something different and not a regular old writing or reading assignment ▪ Yes it was interesting, something different ▪ I do not do well just listening to someone talk
Q2: What were the strongest features of the webinar?	▪ The fact that you can rewind or start over if a concept is not understood ▪ The presenters seemed very knowledgeable about the subject ▪ Easy to navigate back and forth through the presentation ▪ It held my attention better than a written presentation. The Q&A session
Q3: What were the weakest features of the webinar?	▪ It took longer than expected ▪ Slow paced ▪ It wasn't very exciting ▪ They could have made the PP a little more snazzier ▪ Nothing much
Q4: How could the webinar assignment be changed in the future	▪ More options, and topics variety ▪ Instead of PowerPoint have a video ▪ Its fine as it is ▪ I liked the way it was

Most comments to the first question were positive in nature. If at all possible in the future, it would beneficial for the instructor to preview the webinars. Similar to other class ad-ons [videos, video clips, guest speakers], the value of the exercise depends on the quality of the presentation. Also, flexibility in choosing topics which are of the interest to the students will more likely engage them more. When looking at the weakest features, the lecture quality comes through, which would be tough to spice up without added features such as video. However, to some extent, the lecture quality may be a casualty of the currency of the information. While not excusing poor or boring presentations, it seems clear that many of the webinars – in particular the IT webinars – are focused more on getting the most current information out rather than having punchy or exciting PowerPoint slides. Surprisingly, over 75% of the students liked the way the assignment was presented, and didn't offer any improvements.

Graduate class

In the graduate class, the MIS core class for MBA students, each chose a webinar of their choice. The topic needed to be relevant to the class and students were encouraged to find a webinar that was either personally interesting to them or related to their work. The assignment included viewing the webinar, preparing and delivering a 3 to 4 minute presentation on their webinar, and handing out a one paragraph summary of the webinar that included the website in case the topic was of interest to other students in the class. One goal of this assignment was to encourage individual students to go into more depth about an IT topic they were interested in. The second goal was to illustrate to the class the breadth of IT's products and applications in the 21st century. The third goal was to re-enforce other class material as it related to the webinar. Students often did this on their own in their presentation or the instructor would note the connection after the presentation. The fourth goal was to be sure each student, as a professional manager, was comfortable searching the Internet.

Numerous online sources for webinar listings were provided by the instructor but, as stated before, the focus for the students was to find a topic in which they were interested. The class was given several weeks to find a webinar of interest. A few minutes were spent in each class discussing what students had found and how they had searched the Internet to find what they wanted. The instructor spent one-on-one time with the few students who had a problem finding a suitable webinar. The presentations were scheduled to be given over the last six weeks of the class, with about 4 presentations made each week.

The same questionnaire that was given the undergraduate class was handed out to the graduate students after completion of the assignment. This group was a bit older (53% over 25), 50% male, and again were studying in all management areas. Table 3 summarizes the results of the first six questions presented on the five point Likert Scale:

Table 3
Perceptions of Webinar Assignment: Graduates

[n=25]

Question	% of Respondents replying excellent or very good
How accessible was the webinar?	84%
How was the quality of the audio?	80%
Knowledge of speaker	97%
Clarity of the presentation	88%
How well your interest was kept	44% very well or well
Ease of following webinar	68% very easy or easy
Overall rating of webinar watched	80% excellent or very good

These results mirror those of the undergraduates. A smaller percentage indicated that the webinar held their interest [44% vs. 55%], but higher percentages found the technical features [accessibility, quality, and clarity] acceptable, and only 1 person felt that their speaker was not knowledgeable.

The same open ended questions were asked of the graduate students. Sample responses are found below in Table 4.

Table 4
Open Ended Questions related to Webinars: Graduates

Question	*Representative Responses*
Q1: Did you like the webinar assignment?	▪ Yes, you were able to view what companies offer to consumers to help with other business practices ▪ Yes, work related, appropriate to course objectives ▪ Yes, very informative and opened up future area of interest ▪ Yes, I thought it was interesting to hear everyone else's presentation. It gave the class a feel for what's out there ▪ It was OK.
Q2: What were the strongest features of the webinar?	▪ Content ▪ Speakers' knowledge of info ▪ Easy access, quality good, speakers knowledgeable ▪ The time (less than 25 minutes)
Q3: What were the weakest features of the webinar?	▪ The format, basically listening to a live voice while looking at a static PowerPoint presentation. It didn't keep my attention ▪ It was long ▪ Mine was not a live webinar, and there was not an opportunity to ask questions ▪ Speaker was not dynamic to hold complete interest

Q4: How could the webinar assignment be changed in the future	▪ Class could watch a webinar ▪ More than just slides ▪ It was fine ▪ In my opinion it was very good

For question #1, all but 1 student liked the assignment, and the graduate students were more expressive in their answers. The length of time was too long. Most of the webinars were an hour or so and several students stated decidedly that they would prefer a shorter presentation. The suggestions for improvements varied from fine as it was, too cutting out the executive summary.

CONCLUSIONS

Overall, the results of using webinars in both a graduate and undergraduate class was successful beyond expectations. Combining the two groups, over 75% gave their webinar an overall rating of very good or excellent. In the graduate class – a population that tends to be very direct about what they like and don't like – the in-class discussion of the webinars was even more positive than the already positive written comments.

Some of the enthusiasm is likely attributable to the fact that a webinar assignment is new, something different. This will, no doubt, fade as webinars become more commonplace as a class assignment. For future use of webinars in the classroom, two overall suggestions permeated both classes -- when possible, try to match the webinar to the student interest and find webinars that are under one hour in length,

Some of the graduate students wanted a more structured assignment, like the undergraduate students had, with a list of webinars to choose from. In addition, a few students suggested that the instructor should review any and all of the webinars on the list in order to ensure quality. Some did not like the added component of needing to search the Internet (with guidance from the instructor) to find their own webinar. One graduate student suggested that, in the future, the instructor should choose a webinar or two and show those webinars during class time. These suggestions all fit under the traditional conception of the classroom and classroom teaching.

Today, with the rapidly changing and expanding world of business and information systems, the explosion of teaching technology, and given the comfort level of students with technology such as the Internet and learning management systems, the conception of the classroom needs to continue to expand beyond the four brick-and-mortar walls. The webinar assignment described in this paper is an example of instructors planning "outside the classroom", that is, developing guided assignments to be done by students outside the classroom in order to take advantage of the many resources – in particular digital resources -- outside the traditional textbook. We believe that using webinars along with podcasts and wikis, to name two other new approaches, are the wave of the future to keep our students engaged as well as provide a means for exposing our students to the explosion of current material available.

INTRODUCTION TO BUSINESS: WINNING BUSINESS PLANS

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ABSTRACT

This paper briefly describes the required "Introduction to Business" course as currently taught at Northeastern University. A unique feature of this course is its partnering with a large retailer. As a partner, the company provides senior executives as guest speakers throughout the course. Thus, when the students are studying marketing, the V.P. of Marketing comes on campus to talk to the class. As a primary course requirement, the students must develop and present a business plan of a start-up, fictitious company to provide a product or service to the partnering corporation. Each fall, 80-90 teams compete to be in the "Fab Four". These are the four team's business plans chosen as the "Winning Teams". Their selection is based upon their "great idea", their written business plan and their final oral presentation.

Introduction to Business: Winning Business Plans

INTRODUCTION

This paper is a brief description of the CBAU 101 Introduction to Business course and the winning "business plans" written and presented in the three years as currently taught at Northeastern University. This course, required for all College of Business Administration freshmen entering in the fall, was completely revised in the fall, 2003.

BACKGROUND

Prior to the introduction of this course, a significant complaint by the Central Administration of the University was the low retention rate of freshman students by the College of Business Administration (CBA). At a visit by the President and Provost to the CBA's Dean and Group Coordinators (Department Chair) meeting in the late 1980's it was pointed out to the President that, although these were officially CBA freshman students, they did NOT take a CBA course until their sophomore year.
At that time, it was decided that CBA freshman should be "introduced" to CBA! Consequently a six (6) week, non –credit, required course was started and staffed by volunteers. A year later, the course was expanded into a one (1) credit, quarter course. It has evolved into our current, four (4) semester hour, course taught by faculty as a part of their teaching load. The current course was developed during the winter, spring and summer of 2003.

THE COURSE

The purpose of the course is to provide the students with a broad overview of "business". The basic concepts of business such as: marketing, management, supply chain and operations, accounting, finance, information technology, human resources and strategy, are all introduced. These concepts are introduced through: readings, lectures, mini- cases and the term project. The text is a "customized" text consisting of papers, mini-cases,

articles, exercises and selected chapters from a published text. The term project is the primary thrust of the course and is 50% of the course grade. In this course, the students study business concepts but, in addition, are expected to apply them by preparing a business plan of a fictitious company.

This fictitious company is expected to provide a "good" or 'service" to a real company, TJX, which has annual sales of $16B and is headquartered in Framingham, MA. It is comprised of the following: TJ Maxx, Marshall's, Home Goods, AJ Wright, Bob's Stores, Winners (Canada), Home Sense (Canada) and T. K. Maxx (UK)

TJX was selected because it is an "off- price" retailer and we believe that students can easily relate to retailing. TJX has agreed to "partner" with the college pertaining to this course. The immediate past President/CEO was on the college advisory board. Other members of the Advisory Board have volunteered their organizations as "partners" in the course. However, the faculty prefer TJX because of its size and, more importantly, because it is a retailer, a type of business that all students have patronized and feel comfortable working with.

The President/CEO or Executive V.P. comes on campus to speak to all CBAU 101 students about the third week of class. Prior to this appearance, we have discussed in some detail the latest annual report of TJX. Approximately every two weeks a member of TJX's senior management comes on campus to describe their function and how it uniquely fits into the organizational structure at TJX. For example, when we discuss marketing and customers the marketing vice president is the speaker that week.

While these speakers come with prepared presentations, it should be noted that both the speakers and the faculty are fully expecting the students to be actively engaged in the Q&A. Many times, the time for Q& A is as long as the presentation itself.

The students are divided into teams of 4 or 5 students each. These teams must come up with their "Great Idea" and then prepare a business plan. During the term the teams make class presentations on: their great idea, market and customer profile, and financial plans. The semester ends with a "final presentations and submission of a written proposal."

"FAB FOUR"

The final presentations are timed and are expected to be 10 minutes long. The written business plans usually are 30-35 pages long with a one or two page Executive Summary. Of the 80 or so teams, the top (four) 4 are selected to present their "great idea and plan" to the senior executives of TJX. The selection process for the top four is done in each course section, with the last two classes allocated to the final presentation by each team. In addition to the regular faculty member attending these classes one of the other course faculty teaching this course are also assigned to listen to and evaluate the final presentations. After the last class of presentations, the faculty meet and discuss what they consider the "best" of the presentations.

The attending faculty member briefly discusses which, if any, he or she thinks was an outstanding presentation and "Great Idea". Eventually, the faculty reach a consensus and four are selected and notified. The next day, they present again and receive feed back from two or more faculty. The following day, these four (4) called the "Fab Four" make their presentation to TJX executives, the faculty and usually about 300 of their fellow students. Their names, the title of their business plan and their supervising professor's name are engraved on a wall plaque mounted in the undergraduate student lounge. In

about week three or four, when the teams are focusing upon defining their "Great Idea" and informally discuss it with their respective faculty, the faculty member will tell them that "they can proceed with this idea but that it is not sufficiently new or different to get them into the "Fab Four". They can go ahead and do it and as a long as they do an excellent job, they will earn an "A" for this part of their course grade (50%) but will most likely NOT be selected for the Fab Four.

Some of the ideas presented in these Fab Four presentations generated discussions among the senior executives and some did not. (at least not on the day of the presentation!) Two that drew positive comments/ feedback are: 1. The Concept for Kids proposal for the LCD screen on the shopping carts, and 2) The proposal to set up an internet, on-line shopping site. The first one they liked because they decided that it would encourage longer "treasure hunts" and consequently, more sales. The second one, they winked and smiled and said: "that's something were working on right now. We expect to launch it within a few months." What happened? Just a week or two ago, a senior VP told us about an article describing a company doing what Concept for Kids proposed. With respect to the on-line shopping site, it was up and running for about a year or more. They were losing money with it, so shut it down. As it turns out, with TJX's strategy of buying what's available, usually after a "season" has started, and not being able to guarantee all sizes and colors, internet shopping was found not to be amenable to TJX's inventory strategies.

THE WINNING BUSINESS PLANS

2003 Concepts for Kids

Concepts for Kids was the first team to propose offering an enhanced version of the everyday shopping cart. They proposed attaching an LCD screen on the shopping carts to entertain children while mothers shop. **NOTE**: The TJX executives loved this idea primarily because they liked the idea of the shopper spending more time in the store, "treasure hunting".

2003 E.A.S.Y Alterations

E.A.S.Y Alterations proposed offering tailoring services at TJ Maxx stores in the Greater Boston area. Among the TJX Company stores only Bob's currently offers alterations and this is restricted to the cuffing of men's slacks.
NOTE: As of October, 2006, Bob's stores is still the only division offering alterations. This presentation generated some interesting debate among TJX executives. Some thought that it was a good idea , and others thought that TJ Maxx and Marshall's should stay out of the alterations business. As an additional note, TJX purchased Bob's Stores in 2003 and Bob's Stores was an independent store chain providing men's pant's leg alterations.

2003 TimeMaxx : Item Locator

TimeMaxx: The item locator proposed a touch –screen computer that enables the customer to pinpoint the desired item's location within the store. This group's objective was to save time for the customer. **NOTE:** The TJX philosophy is to keep the customer

in the store longer. They want the customers to go through a " treasure hunt" process, and the longer the better.

2003 rEtail

rEtail proposed that the Marmaxx division (TJ Maxx and Marshall's stores) develop an internet retail sales site.
NOTE: This idea was well received by the attending TJX senior executives because they were developing such a web at the time. The internet sales site was launched a few months later. Approximately a year and a half to two years later TJX shut it down , because it was losing (costing) too much money. TJX's buying/ inventory strategies make it very difficult for a web site for retail sales to succeed because of the high turnover in inventory items and the fact that the company doesn't necessarily stock items for the entire season

2004 Synergy

Synergy proposed a reality television show entitled: "Maxxed Out" Using a TJ Maxx or Marshall's locale in which two guests compete in a "treasure hunt". They would advertise the show as a "reality makeover show". **NOTE**: This concept was of interest because it focused upon the college age or 18-30 market, which is a market that TJX would like to attract more than it does. Until recently, these TJX stores did not do extensive advertising, so it was viewed as a clever/unique advertising scheme for TJX.

2004 Quintessential Connection

Quintessential Connection proposed self-service checkout system for Bob's stores. **NOTE** : Although the concept was interesting , the TJX executives believed that Bob's Stores doesn't generate the crowds at the checkout lanes to justify the need for such systems.

2004 Rack This! Corporation

Rack This! Corporation proposed being a distribution of unique and innovative rack and shelf fixtures for retail stores. **NOTE**: While most Fab Four presentations are aimed at keeping the customers in the store longer, or attracting new customers into the stores, this one was focused upon reducing operating cost. Moreover, it was seen as a possible way of better displaying store merchandise.

2004 Propel

Propel proposed remodeling dressing rooms in TJ Maxx and Marshall's stores. **NOTE**: The TJX executives took this to heart. However, this year a TJX executive said that their goals are to "meet" customer expectations and that spending money to "exceed" expectations is not considered money well spent.

2005 LEGZ Incorporated

LEGZ Incorporated proposed a TJX Entertainment Network using the medium of screens to display promotion and sales information, display TV programs created to inspire customers to shop and to broadcast programs for children.

NOTE: TJX executives believe that the longer a customer stays in a store, the more likely they are to find something during the "treasure hunt" process to buy.

2005 Mobile Advertising

Mobile Advertising proposed broadcasting advertising to cell phones that came within 300 feet of a TJX store. The system would cause your cell phone to ring and if you answered it, you'd receive a text message inviting you to come into the nearest TJX store and offer you a "promotion" of some kind to lure you in.
NOTE: TJX was intrigued by this concept but they are followers and not leaders in technology, so it is doubtful it received much discussion at headquarters.

2005 HomeCorner

HomeCorner proposed running domestic workshops in five local HomeGoods stores. The workshops would run in five week cycles, rotating from one store to the next for five weeks
NOTE: This is the first of the Fab Four presentation designed specifically for a non-clothing division such as TJ Maxx or Marshall's. We believe that TJX was pleased to see a project aimed at Home Goods, especially one that might attract additional customers in to the stores.

2005 Smoothie Land

Smoothie Land is the first "food operation" selected for the Fab Four. **NOTE**: Although TJX is seeking to attract a younger demographic into their TJ Maxx and Marshall's stores, to date they do not appear interested in allowing food operations into their stores.

Summary

We believe that the results achieved in the course are directly related to the following factors.

1. Design a student- centered course that will excite the student about business, i.e. a practice orientated course.
2. Include in the design "course management" practices such as: weekly meetings of the faculty to share experiences, materials, techniques, etc. These meetings include a "debriefing "of the previous week and preparation, discussion and an explanation of the next week's classes and materials.
3. Get the students involved early into the team concept and team dynamics.
4. Partner with a corporation (in this case TJX) as an "umbrella" concept for the course.
5. The involvement/inclusion of guest speakers from the partnering corporation
6. A relatively simple framework for the course, i.e. a simple course outline sticking to a few, basic core concepts.
7. Set expectations high
8. Get student feedback/assessment and plan for continuous change.

FATHER KNOWS BEST?
THE INFLUENCE OF TELEVISION VS. PERSONAL ADVICE ON CAREER DECISIONS

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ABSTRACT

This study examines the factors that influence career interests. In addition to more traditional sources, such as advice from parents and career counselors, the effect of television on vocational decisions is considered. Using a policy-capturing survey, 24 business students rated hypothetical careers, portrayed either positively or negatively by five sources of influence. Although many policy-makers and parents express concern over the extreme impact of television on the young, our findings indicate that while television played some role in the decision-making process for every respondent, it was never the most influential source. Of the five factors examined, parents and friends had the greatest effect on career choice. Through this study, the real impact of television on vocational decisions is revealed, and the implications for practitioners and educators are identified. The paper concludes with future research possibilities in this emerging area of study.

The Societal and Academic Implications of Electronic Games Use

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ABSTRACT

Over years, information technology and especially electronic games industry made an incredible progress from primitive graphics to sophisticated, three-dimensional virtual reality. Despite the fact that these games started to occupy a substantial amount of time in people's - especially children's - lives, research has been lagging in studying the effects of these electronic games on users. Unlike prior research, this paper investigates the effects of computer and electronic game habits of young adults on their plans for future. We surveyed 438 children, consisting of 9-12 graders, at a school in the south-eastern part of the US. We collected data concerning their video game playing habits, computer usage, academic achievement, future coursework/career selection, parental guidance and social interactions. Our findings demonstrate that there is a significant relationship between student's electronic game use and academic achievement.

Keywords: electronic games, information technology use, information technology and education.

INTRODUCTION

The role of information technology (IT) as an enabler for increasing productivity and improving quality in a work setting has been well established. Many studies have therefore focused on investigating the underlying factors that impacts the adoption of various types of IT in variety setting [2] and further exploring the relationship between individual, organizational and environmental factors and the use of such IT. Likewise, many studies have been conducted with the intention to capture the impact of adoption and use of IT in educational setting. Despite the wealth of studies on technology and education, questions about the acceptance of information technology among younger students remain unaddressed. In one much-cited research commentary, Alavi and Leidner call for increased research on technology-mediated learning (TML). They recommend that "the explicit relationships among technology capabilities, instructional strategy, psychological processes, and contextual factors involved in learning" is explored.

Considering the fact that public exposure to computers has changed drastically ever since the Internet became available to the general population in this paper we focus our attention to the role of IT in young learners' academic formation. Census Bureau (2005) reports that as of 2003 76.2% of households with school age children (6 to17 years old) had one or more computers and 67% of them were Internet users. Many households actually have more than one computer, the average is 1.2 per household, and this figure is

expected to increase to 2.3 by drastic changes in the adoption of information technology in public schools. The adoption of Internet in schools has been remarkable. For example, the percentage of public schools with Internet access has increased from 35 percent in 1994 to 78 percent in 1997. These numbers are only a few examples that demonstrate the rate of diffusion of information technology among the U.S. institutions and the general public.

BACKGROUND

Research investigating the relationship between time children spends on electronic games and computer usage (such as video games, computer games, email, instant messenger) and academic performance has been lagging, especially from MIS research perspective. There are diverse research that has been performed by educators and behavioral scientists targeting either educational or behavioral issues most often from a negative perspective. However, the dearth of research in this field contradicts the trends in the market place. Technology and therefore electronic games are improving at a rapid rate, as is the number of users. In 2001 in US electronic game related sales had reached over $9 billion and it is projected that the growth will continue with geometric proportions. Furthermore according to Nielsen Interactive Entertainment's third annual Active Gamer Benchmark Study the adoption of such electronic games (computer and console based) is steadily shifting from "young boys" to young adults of both genders.

As it is argued for computers there are many positives that can and are generated by electronic game usage. Subrahmanyam, Kraut, Greenfield, and Gross addressed some of these in New Forms of Electronic Media [4]. This study provides us with some insight to the students' use of information technology, in that it addresses the increase of personal computers, and electronic games in homes and that usage of these technologies by teenagers is increasing. It centers on the metrics of teen and pre-teen usage in terms of length of play, demographic and gender differences. In a study conducted by Pillay, Brownlee, and Wilss [3] researchers take the educational perspective of electronic game playing. They examine the types of game and the cognitive skills that are engaged and therefore enhanced during game play. They even allude to the possibility that electronic games could encourage students to go into technology areas in the statement, "Anecdotal evidence suggests that many information technology experts learnt their basic skills by playing recreational computer games."

Such studies demonstrate it is plausible that experience with various forms IT could have a varying influence on young adults' behavior, academic performance, as well as future career path. Indeed, there are a many questions that need to be answered in the area of electronic games usage among the teenagers, the impact it may have on student's current being, and how much a role they play in shaping up a student's future.

Investigating many aspect of IT / young learner interaction is enticing, in this study we will only focus on what role, if any, IT (electronic games or otherwise) plays in students' academic achievement.

RESEARCH QUESTION

What is the role of IT (electronic game/computer) use in a student's academic achievement? This a fundamental questions that require an in depth understanding, especially when considering a) the IT investments budget challenges and b) educational outcome expectations that are constantly faced by academic institutions.

RESEARCH FRAMEWORK

Borrowing from previously established models and theories we hypothesize that four user characteristics as being the key determinants of student's academic performance (SAT score); electronic game use, electronic game challenge level, extracurricular academic activities, emphasis placed on core courses. These items were determined as unique contributing factors in addition to student's routine use of IT in performing their daily tasks or expected coursework preparedness. The research model is represented in Figure 1.

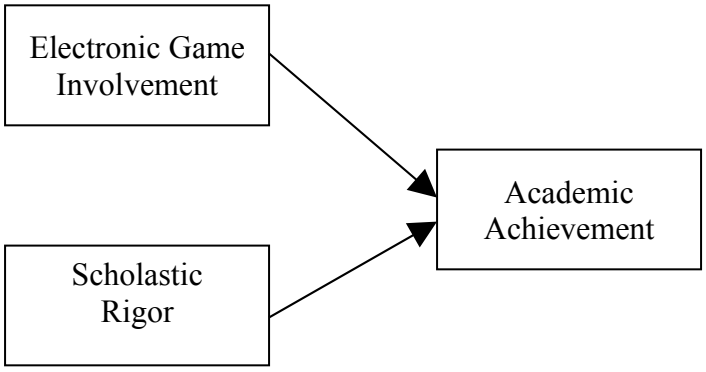

Figure 1. Proposed Research Model

METHODOLOGY

In search for answer for the research question recently we conducted a study in a public high school located at south eastern United States. The study protocol, consent procedure, and the survey instrument were approved by the University of South Florida Institutional Review Board. 438 high school students consisting of 9-12 graders participated in a survey. They were administered a 92 item questionnaire that was pilot tested at a charter school students. Part of the survey items were selected from previously conducted Department of Education Study and constructs from Theory of Reasoned Action and Social Cognitive Theory were included along with demographic items. Students completed the questionnaires during the first 30 minutes of the first class and there were no individual identifiers recorded to maintain anonymity.

DATA ANALYSIS & RESULTS

Out of 483 students surveyed 58% was female. 39%, 33% and 28% were 10^{th}, 11^{th} and 12^{th} graders respectively. The students those who reported had a mean GPA of 3.45 (N=423, SD=0.65) and a mean SAT score of 1041 (N=106, SD=284). 274 students identified themselves as electronic gamer and provided us with 271 different game labels. When categorized and rated based on the National Game Labeling Standards (such as A: Adult, M: Mature, E: Everyone, etc) only 46 of them had Adult or Mature Rating and the rest were rated as "Everyone" or "Teenager" (about 83%). These numbers are contrary to the popular belief that the kids are into "violence" and "sexually explicit" games.

In order to test the proposed research a subset of the data was extracted. The 106 students who reported their SAT scores these were the selected group for the purpose of the analysis. Six of those had incomplete records and were eliminated from the sample leaving us with 100 usable data for analysis.

Confirmatory factor analysis (CFA) was used for assessing the validity for our measurement scales. This was performed using the partial least squares (PLS) technique using Visual PLS 1.04. Raw data was used as input to the PLS program, and path significances were estimated using the bootstrapping re-sampling technique with 100 sub-samples. Both convergent and discriminate validity were satisfied. The next step in our data analysis was to statistically test our proposed research model (Figure 1) as whole and individual paths in this model. This analysis was also conducted using PLS.

The proposed model explained 33% of the variance in the academic achievement, SAT score. Examining individual path effects, we find that both of the paths in the proposed models were significant at $p<0.01$. Both the electronic game involvement and the scholastic rigor had a direct positive effect on academic achievement ($\beta=0.39$) and ($\beta=0.36$) supporting the posited positive role of electronic games in academic achievements.

DISCUSSION AND CONCLUSIONS

Key Findings

Our study proposed the role of electronic game use as a positive determinant of high school age student's academic achievement. The study results demonstrated a significant direct positive effect of electronic game use on student's SAT scores. Our study demonstrates that gaming technologies can contribute to students' learning activities if successfully integrated in both academic and social setting. Currently such IT use is self regulated by the young learners who may not be capable of managing resources meaningfully.

Limitation of the study

The findings of this study should be interpreted in light of its empirical limitations. The first limitation is our measurement of the electronic game usage construct. Our self-reported usage measure was certainly not as accurate, unbiased, or objective as usage data collected from actual game logs. Second, for the sake of simplicity and parsimony of our preliminary research model, we considered electronic game use and scholastic rigor as sole predictors of academic achievement. . However, there may be additional predictors of academic achievement as we have eluded earlier such as social interaction, self esteem and such. Future research may consider such factors to improve the explanatory power of our model. We hope that this study will motivate future researchers to examine in further depth this interesting but barely explored area of IT research.

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DEFINITION OF RELATIONAL DATABASE STRUCTURES USING PRIME NUMBERS AND CHECKSUMS

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ABSTRACT

A technique for representing relational database structures mathematically using the properties of object patterns (in the tradition of the "Gang of Four") combined with the properties of prime numbers has been proposed. This paper extends the technique, using checksums derived from the object patterns and prime numbers of a relational database structure to represent an entire relational database structure of any reasonable size as a single alphanumeric string.

Keywords: prime numbers, logical data model, patterns, checksums

INTRODUCTION

The "Gang of Four," in their book entitled *Design Patterns: Elements of Reusable Object-Oriented Software* [4], demonstrated that common problems in software design could be productively approached with a disciplined understanding of reusable software patterns. Chmura and Heumann [2], building on their work, demonstrated that common problems in relational database design could be productively approached with a disciplined understanding of reusable relational database patterns. More recently, Banda, Chmura, and Heumann [1] have demonstrated that the structure of a relational database table, including the key structure, can be expressed mathematically using prime numbers and a minimum of metadata.

A question which this paper attempts to resolve is: "Can an entire relational database structure be expressed mathematically, with minimal reference to metadata?" Using the model database developed by Costain [3] (used by permission), we propose to present one possible solution to the problem. Our result will be a single alphanumeric string which can be generated automatically. Reconstruction of the actual relational database structure in its entirety is not possible using only the alphanumeric string: reference to the metadata is required.

One application of this technique could be the rapid determination of changes in a relational database structure between two configurations. By comparing the checksums of two relational databases of interest, a database administrator should be able to quickly spot certain types of differences, including but not limited to addition or deletion of tables and columns.

THE MODEL DATABASE

Figure 1 shows the general structure of the "College" relational database as a logical data model expressing the following:

- Each COURSE may have zero, one, or many PREREQUISITEs.
- Each STUDENT may receive a GRADE for zero, one, or many COURSEs.
- Each COURSE may yield a GRADE for zero, one, or many STUDENTs.

This structure is intentionally kept small for illustration purposes. Note that PREREQUISITE is a recursive entity.

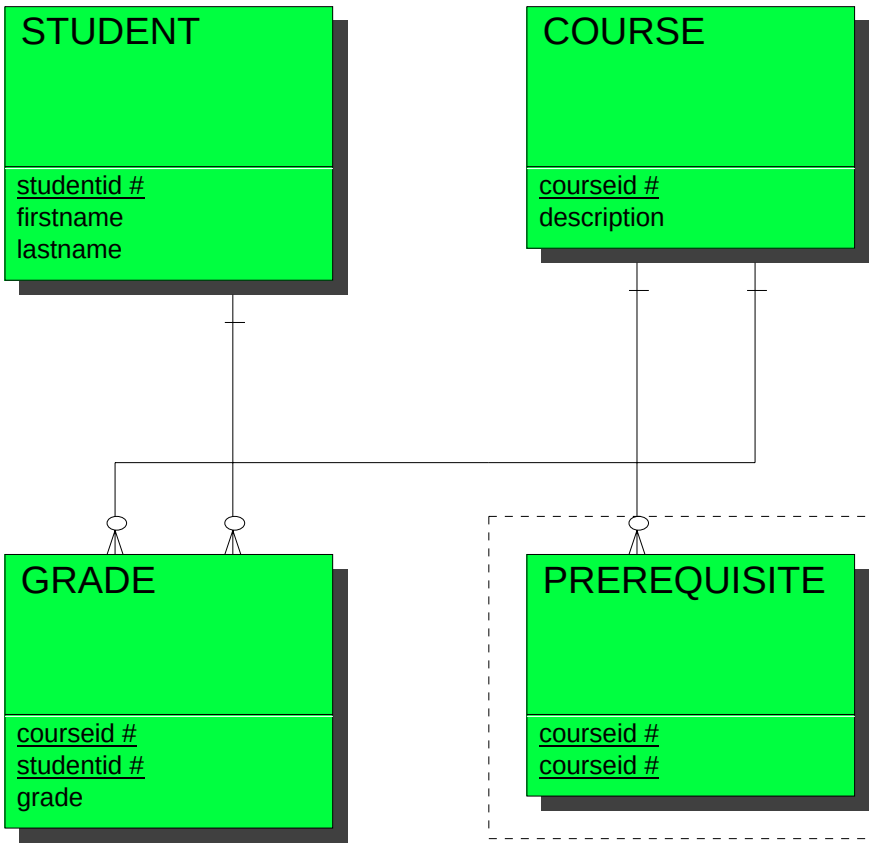

Figure 1: Logical Data Model for the College Database

Each column in every table must be of some datatype. We need to assign a unique prime number to specify the datatype of each field. One possible solution is shown in Table 1:

Datatype	Datatype Prime Number	Data
CHARACTER	2	Text of any kind
NUMERIC	3	Numbers
DATE/TIME	5	Date or time
CURRENCY	7	Monetary values
BINARY	11	Binary data
… more	… more	

Table 1: Datatype Assignment

ASSIGNMENT OF PRIME NUMBERS AND MATHEMATICAL PRODUCTS TO TABLES

The structure of each database table may now be expressed in terms of prime numbers (Tables 2 through 5). Note that

- the prime numbers assigned to each datatype above are used in identifying the datatype of each column in each table,
- an additional prime number not already assigned is assigned to each key field, and that
- the additional prime number assigned to each key field is unique.

After each prime number has been assigned as required, the mathematical product of the prime numbers is computed for each table. A unique table identifier is constructed by concatenating the mathematical product of the prime numbers with non-unique identifiers for each column. To keep the final checksum string short, we have chosen column identifiers consisting of only the first character of each column name (the order of the column names is insignificant). Tables 2 through 5 show this protocol applied to the COLLEGE database tables:

Data Name	Datatype	Primes assigned
StudentID *[key]*	NUMERIC	3, 13
LastName	CHARACTER	2
FirstName	CHARACTER	2
Product = 3 * 2 * 2 * 13 = 156	**Table Identifier** = 156SLF	

Table 2: STUDENT Table

Data Name	Datatype	Primes assigned
CourseID *[key]*	NUMERIC	3, 17
Description	CHARACTER	2
Product = 3 * 2 * 17 = 102	**Table Identifier** = 102CD	

Table 3: COURSE Table

Data Name	Datatype	Primes assigned
Student ID *[key]*	NUMERIC	3, 13
CourseID *[key]*	NUMERIC	3, 17
Grade	CHARACTER	2
Product = 3 * 3 * 2 * 13 * 17 = 3978	**Table Identifier** = 3978SCG	

Table 4: GRADE Table

Data Name	Datatype	Primes assigned
CourseID *[key]*	NUMERIC	3, 17
CourseID *[key]*	NUMERIC	3, 17
Product = 3 * 3 * 17 * 17 = 2601	**Table Identifier** = 2601CC	

Table 5: PREREQUISITE Table

CONSTRUCTION OF THE CHECKSUM STRING

We can now construct the checksum which models the COLLEGE database in a single string. The string is constituted as follows:

checksum = database identifier
+ {table identifier}

We have chosen to use 3 letters (COL to represent "College") as the database identifier to keep the checksum string short. The table identifier for each entity in the database is added after the database identifier.

A database identifier of any reasonable length is possible. The order of the table identifiers is not meaningful, although mathematically smaller numbers might be listed first by convention. For readability, we have inserted a dash ("-") between the elements of the checksum string. Our checksum is defined as

COL-156SLF-102CD-3978SCG-2601CC

Our checksum is readable, it can be created easily, and it carries much of the vital structure of the database. It is easily implemented and checked.

POTENTIAL APPLICATION

We see the following as applications for this technique:

- Database integrity (Has a structural change occurred between two copies of the same database?)
- Error detection (Does an invalid pattern exist in the structure?)
- Estimation (How big/how complex is the structure?)
- Interface construction (How should this interface be designed? We hypothesize this as an application.)

CONCLUSION

Using prime numbers and a minimum of metadata, we have composed a single checksum alphanumeric character string which expresses much of the vital structure of a relational database. This technique may be useful in determining database integrity, error detection, estimation, and interface construction.

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VOIP SECURITY ISSUES AND RECOMMENDATIONS

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ABSTRACT

VoIP is the hottest trend in telecommunications. Prior research shows that the VoIP technology is at the introductory stage in technology adoption with solid growth expected over the next few years as both consumers and businesses adopt VoIP technology to cut costs, improve productivity and efficiency, integrate with other applications, seek enhanced capabilities, and digital convergence. But, security issues tend hinder its adoption. In this study, we identify VoIP security challenges, risks and threats, and offer some recommendations for mitigating these risks.

Keyword: MIS, IT, Security, VoIP

INTRODUCTION

Voice over Internet Protocol (VoIP) is the hottest trend in telecommunications (Walsh & Kuhn, 2005). VoIP is "the transmission of voice over traditional packet-switched IP networks" (Walsh & Kuhn, 2005). VoIP is also known as Internet telephony or IP Telephony. The analog signals (voice) are converted digitized packets and then sent over a IP network. The digital packets have a destination address but they follow no fixed path. At the destination packets are re-assembled and delivered. To enable VoIP, broadband access, a computer, and software are required. Additional hardware such as servers, switches, routers, and others may be required depending on the volume and nature of traffic. Readers are urged to consult VarShney, Snow, McGivern, & Howard (2002) for an excellent review of the VoIP history and technology.

VoIP permits the integration of data, voice, and video into one communication channel. The term digital convergence refers to this phenomenon of multiple media delivered over a single network. Some of the applications and services include PC based distance learning solutions, video conferencing, live webcasting, video streaming, collaboration and team management software, security surveillance, contact center applications, remote multimedia solutions and unified messaging ((Tobin & Bidoli, 2006).

To compete in the new economy firms including are looking at many strategic options. Recent events suggest that firms in particular large ones are exploring the use of Voice over Internet Protocol (VoIP) as a means to cut costs, to improve productivity, and the firm's strategic position. The use of VoIP enables a firm to reduce costs, improve worker and organizational

productivity, provide greater functionality and better integration with computer based applications, and improve the strategic position of the firm.

Recent studies project VoIP market to grow (Roberts, 2005a) significantly over the next few years. An Osterman Research Report dated February 2005 suggests that VoIP penetration of US organizations will increase from 10% to 45% by the end of 2007. Another Osterman Research Report, also dated February 2005 suggests that approximately 17% of US organizations have either completed voice and data convergence or are near completion. A Juniper Research report dated September 2004 forecasts that VoIP adoption will rise to 17% of US households by 2009 from its current value of 1% of all US broadband households in 2004. The factors that promote the growth of VoIP include low cost of the software, wide availability of analog adapters, growing availability of broadband, and relative high costs for traditional calls (Roberts, 2005a).

VoIP security is a major issue to both Network administrators and managers. A security outbreak is likely to result in loss of service, denial of service, eavesdropping, spoofing, toll fraud, spam, unavailability of emergency calls. Research shows that VoIP security continues to be the key barrier to VoIP adoption (Sass, 2006). The practitioner literature is rich with "How to" articles on VoIP security. As security plays a key consideration in VoIP acceptance and adoption, the purpose of this article is to review the literature, identify security risks, and suggest recommendations. This article is organized interms of 6 sections. Next, we discuss VoIP adoption issues. In section 3, we discuss VoIP security implementation challenges. In section 4 identify and catalog VoIP security threats. Guidelines for securing a VoIP network are in section 5. In section 6 we provide some summary remarks.

BACKGROUND TO VOIP & VOIP SECURITY IMPLEMENTATION CHALLENGES

Transition to a VoIP network increases the risk profile of a corporate network due to complexity, the presence of new access points to the network, new routing patterns and configurations, the use of new devices and protocols which in turn increases the number of vulnerable points, and the presence of a new channel for blended threats (Roberts, 2005b). Walsh and Kuhn (2005) identify several challenges associated with implementing VoIP security measures. These challenges deal with supporting protocols, VoIP vs. data network security, and the need for new technologies. Below we provide a brief description of these challenges as noted in Walsh and Kuhn (2005).

H.323 and Session Initiation Protocol (SIP) are the common protocols used in VoIP networks. H.323 is based on the recommendations of the International Telecommunication Union. It encompasses other protocols such as H.225, H.245, and T.120. H.323 provides the necessary specification for audio and video communication in packetized network environment. In addition to its use in VoIP, H.323 is also used in applications such as NetMeeting and Ekiga. SIP is an application level protocol and is the IETF specification for a two way communication session. Initially SIP was designed to be simple and elegant. It is text based and inherited some

aspects of Hypertext Transfer Protocol (HTTP) and Simple Mail Transfer Protocol (SMTP) (Roberts, 2005). But, over the years SP has become more complex. Readers are urged to visit the sites http://www.openh323.org/ and http://www.cs.columbia.edu/sip/ for additional information on these two protocols. As the architecture of the two networks are different, the need to implement different protocol specific security mechanisms arises. The addition of upper layer protocols and messaging structures increases the threat profile of the already flawed IP protocol (Sass, 2006).

Many configurable parameters such as addresses of voice terminals, routers, and firewalls exist in a packet network. VoIP networks also have specialized software such as call managers. As a VoIP network has dynamically reconfigurable parameters, many dynamically configurable parameters exist. When compared to data networks, these add additional complexity of VoIP networks. The stricter performance constraints of VoIP also pose additional VoIP security concerns. Issues pertaining to Quality of Service (QoS), Infrastructure, and Security trade offs highlight the differences between VoIP and data networks.

The need to maintain appropriate level of QoS poses some restrictions on security. VoIP networks are mores sensitive to delays than data networks. Latency, jitter, and packet loss all present concerns within a VoIP network. Latency is the delay in packet delivery. Security implementation mechanism such as encryption and firewalls while providing a means to secure the network also introduce delay in network traffic. Such delays can cause the VoIP message to become a mess. VoIP relies on Real Time Transport Protocol (RTP) which does not guarantee packet delivery. Even a packet loss of 1% can make the VoIP call meaningless and thereby affecting the QoS. Jitter is "jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. A jitter buffer can be used to handle jitter" (http://whatis.techtarget.com/). Buffer overflows and improper packet handling can cause security flaws such as Denial of Service and disclosure of system critical information.

As VoIP and data are on the same network, opportunities for eavesdropping exist. Buffer overflows can also cause the insertion of malicious code within the VoIP software. The availability of network information on IP phone can cause security flaws such as downloading from a hacker controlled server. Privacy issues and denial of service (DoS) issues may surface if VoIP web based applications have weak access control, script vulnerabilities, and inadequate parameter validation. The convergence of voice and data traffic may enable hackers to manipulate or functioning of the phone system.

Firewalls are used routinely in many network to protect a network. The use of such firewalls may interfere with the operations of a VoIP network which uses dynamic port trafficking and call setup procedures. Newer tools such as Application Level gateways (ALG) may be able overcome this issue by providing firewalls with necessary instructions from an application aware agent.

VOIP SECURITY RISKS, THREATS, AND VULNERABILITIES

Several techniques and methodologies exist for classifying VoIP security threats. Radware (2005) categorizes the security threats as attacks on VoIP network operating system devices, configuration weaknesses, IP infrastructure attacks, VoIP protocol implementation vulnerabilities, and VoIP application level attacks. Mihai (2006) classifies the threats in terms of protocol layers – signaling, transport, and application. The threats pertaining to the signaling protocol layer are denial of service, man in the middle/call hijacking. Transport layer threats arise from eavesdropping, RTP insertion attacks, and RTCP insertion attacks. Application layer threats pertain to software vulnerabilities. Roberts (2005b) links the security threats to QoS and categories the threats interms of service disruption, service interception, and service fraud and abuse. Roberts also notes the presence of other threats such as fire, flood, earthquake, poorly trained users, and environmental threats.

The VoIP Security Alliance (VoIPSA) a consortium of major vendors, providers, security leaders, and business leaders recently released a report on a taxonomy for classifying VoIP security and threats. The alliance defines security as "1) the right to protect privacy, 2) a method of achieving privacy and 3) ways to keep communication systems and content free from unauthorized access, interruption, delay or modification." The security threats are grouped interms of unlawful monitoring (traffic analysis, packet snooping, spying on signaling, and eavesdropping on content), interruption of service (specific denial of service, general denial of service, physical intrusion, loss of power, and performance latency), unauthorized signal or traffic modification (spoofing and impersonation, false caller identification, signal replay, vocal impersonation, vocal replay, service abuse, improper bypass of adjustments to billing, and improper access to service) and bypassing refused consent.

A large number of threats exist as shown in Table 1. We outline the major ones. A proper knowledge of these threats facilitates the development of security recommendations which are provided in the next section.

GUIDELINES FOR SECURING THE VoIP NETWORK

The following guidelines based on Kuhn, Walsh, & Fries (2005) and Sass (2006) may serve to protect the network from the threats noted previously.

1. To ensure security and adequate performance dedicated VoIP components are necessary.

2. To isolate attacks voice and network traffic should be separated and use DNS/DHCP servers.

3. Ports should have separate MAC addresses and any unused ports should be disabled.

4. Appropriate network architecture should be developed. To mitigate the security problems, Internet Protocol Security (IPsec) virtual private network or secure shell for remote management and auditing and encryption at the router or gateway.

5. As VoIP networks provide greater latitude for eavesdropping and monitoring traffic, physical controls needs to be present and implemented. The hardware should be physically secured.

6. The VoIP operating system should be kept up to date any unneeded service should be disabled.

7. Encrypted and authenticated communication between network components is vital.

8. Hosts on switched ports should not be able to or be aware of traffic not intended for them.

9. If situation warrants, the use of soft phone applications should be discouraged to ensure that these applications with a PC which uses a software and a voice headset. Worms, viruses, and web browser flaws may pose risks for softphone applications.

10. The statutory requirements for VoIP calls may be different for VoIP calls from traditional calls. Legal advice may be necessary for privacy and record retention issues.

11. Use VoIP ready firewalls and other strategies and security mechanism need to be used to prevent packet sniffing.

12. Additional power backups maybe necessary to ensure smoothing functioning should power outages occur.

13. If the need to integrate mobile phone with VoIP system exists, then it is recommended that WiFi Protected Access (WPA) security protocol be used than Wired Equivalent Privacy (WEP) protocol.

14. Firewalls are required if the traffic flows between voice and data networks.

SUMMARY REMARKS

VoIP is a newest technology and researchers speculate that its use could provide rewards to both the individual and the organization. The Telecom Insider newsletter identifies the following seven VoIP trends for 2006 that will have a bearing on its adoption. These include a possible retaliation by Internet access providers who may block VoIP calls, consolidation and partnerships, growth in broadband penetration, growth in wireless use, Session Initiation Protocol (SIP) to become the standard for delivering VoIP calls, regulatory threats, and availability of sophisticated multimedia applications.

The main issue that dampens its widespread acceptance and adoption is security. The purpose of this study is to identify security threats and suggest some guidelines for improving security.

While many of these recommendations are from practitioner sources, it is not clear whether they will adequately negate the security threats. A great deal of academic work needs to be conducted before verifiable security recommendations leads to widespread acceptance of VoIP technology.

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Available upon request from the author.

Term	Definition
Call Black Holing	Any unauthorized method of dropping, absorbing or refusing to pass IP or another essential element in any VoIP protocol which has the effect of preventing or terminating a communication.
Call Pattern Tracking	The unauthorized analysis by any means of any traffic from or to any node or collection of nodes on the network. It includes monitoring and aggregation of traffic for any form of unauthorized pattern or signal analysis.
Call redirection and hijacking	A call intended for one user is redirected.
Call Rerouting	Any method of unauthorized redirecting of an IP or other essential element of any VoIP protocol with the effect of diverting communication.
Conversation Alteration	Any unauthorized modification of any of information in the audio, video and/or text portion of any communication, including identity, status or presence information.
Conversation Degrading	The unauthorized and intentional reduction in quality of service (QoS) of any communication.
Conversation Impersonation and Hijacking	The injection, deletion, addition, removal, substitution, replacement or other modification of any portion of any communication with information which alters any of its content and/or the identity, presence or status of any of its parties.
Conversation Reconstruction	Any unauthorized monitoring, recording, storage, reconstruction, recognition, interpretation, translation and/or feature extraction of any audio or voice portion of any communication including identity, presence or status.
Denial of Service	An attack on a system that causes loss of service to the users of that system.
Eavesdropping	The unauthorized interception of voice packets or RTP media streams and the decoding of signaling messages and the intercepted data
False Caller Identif.	The signaling of an untrue identity or presence.
Fax Alteration	Any unauthorized modification of any of information in a facsimile or other document image, including header, cover sheet, status and/or confirmation data.
Fax Reconstruction	Any unauthorized monitoring, recording, storage, reconstruction, recognition, interpretation, translation, and/or feature extraction of any portion of any document image in any communication including identity, presence or status.
Message integrity	Compromise where the data has been altered in transit
Number Harvesting	The authorized collection of IDs, which may be numbers, strings, URLs, email addresses, or other identifiers in any form which represent nodes, parties or entities on the network.
Packet spoofing and masquerading	Packet or person impersonation which may include fake Caller ID and phishing attempts
Replay attacks	Retransmission of a legitimate session so the recipient device reprocesses the data
Rogue device	A misconfigured or unauthorized device or a device about to fail and displaying aberrant behavior.
Service abuse	The use of Corporate systems in a manner for which it was not intended.
Text Reconstruction	Any unauthorized monitoring, recording, storage, reconstruction, recognition, interpretation, translation, and/or feature extraction of any portion of any text in any communication including identity, presence or status.
Toll fraud	The theft of telephony services.
Traffic Capture	The unauthorized recording of traffic by any means and includes packet recording, packet logging and packet snooping for unauthorized purposes.
Voice mail bombing (Vbombing)	The delivery of multiple voice mail messages (possibly thousands) to a VoIP device and is unique to VoIP networks.
Video Reconstruction	Any unauthorized monitoring, recording, storage, reconstruction, recognition, interpretation, translation, and/or feature extraction of any portion of any moving images in any communication including identity, presence or status.
Voicemail Reconstruction	Any unauthorized monitoring, recording, storage, reconstruction, recognition, interpretation, translation, and/or feature extraction of any portion of any voice mail message.

Table 1: VoIP Security Threats – Definitions from Roberts (2005b) and VoIPSA

GIS EDUCATION ACROSS THE UNDERGRADUATE CURRICULUM

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ABSTRACT

This paper addresses the second phase of a project investigating Geographic Information Systems (GIS). Geographic Information Systems have become increasingly important to decision-making, yet there is evidence that undergraduate students are only being exposed to this technology in a limited number of disciplines. The first phase of the project, a pilot study of the use of GIS in marketing courses, revealed a relatively low level of exposure of undergraduate students to GIS, though several courses did touch on the topic. The current project expands the focus to gather information from faculty in additional subject areas.

BACKGROUND

A Geographic Information System (GIS) is a mapping tool that has application across a wide spectrum of disciplines. Major police departments are using GIS to perform hot spot analysis – looking for spatial and temporal changes in the incidence of crime in different neighborhoods. In health, GIS is playing a major role in epidemiological studies Environmental science is mapping pollution, thermal outflow from power plants, and the extent of wetlands. And in marketing, GIS can be used to help identify target markets, suitable sites for business, and the location of competitors [4]. The companies using this technology to develop business strategies are household names: Nordstrom, OfficeMax, Best Buy, Gold's Gym, Dress Barn and Chase Manhattan among many others. Geographic Information Systems also are the basis for our cars' navigation systems, the maps of troop movements and other events described on TV.

According to Dr. Duane Marble [5], this growth in the use of GIS tools and data is "explosive ... in every sector of the global economy." The GeoSpatial sector is among 14 areas identified by President Bush's "High Growth Job Training Initiative" described by the U.S. Department of Labor. Further, this growth has created "substantial demand for additional, highly qualified personnel [9]." A survey of the postings on Monster.com reveals literally hundreds of positions across various industries that list GIS as a requested skill, as illustrated in the table below. Additionally, a specialized job posting site, GIS Jobs Clearinghouse (www.gjc.com) was created in 1992; it now bills itself as "the most visited GIS/RS jobs site on the Internet." A GIS-education-oriented site, GIS Lounge (www.GISLounge.com), lists 25 websites "specializing in employment in the GIS industry." Yet, outside of geography departments, few universities are offering undergraduate courses in GIS.

Table I Job Postings that Request GIS Skills Monster.com January 2007	
Industry/Discipline	**Number of "GIS Jobs"**
Architecture	18
Engineering	238
Environmental Science	54
Information Technology	262
Marketing	34
Real Estate	11

In light of these developments, the paucity of research into the use of GIS across the undergraduate curriculum is perplexing. There was a brief flurry of activity in the journals of several different disciplines in the late 1990s. For example, Fisher and Conrad [3] examined the use of GIS in the fisheries programs of 42 U.S. universities. That study focused on understanding how GIS research was used in fisheries programs (mapping and modeling) and how students acquired their GIS knowledge (most took courses offered in earth science departments). Essa, Li and Shi [2] conducted a similar survey of civil engineering departments in Canadian universities. They found that faculty incorporated GIS in their classes both via demonstrations by faculty as well as via hands-on activities and assignments focused on student use of GIS software. The study also examined reasons for GIS education not being more widespread across civil engineering programs. More recently, Tas [8] explored the status of GIS education using the Carnegie Foundation's classification system to assess differences across institutions.

Other studies have taken a broader look at GIS across the entire undergraduate curriculum (c.f. Morgan [6]). This research has focused on identifying the disciplines that are using GIS, but not on examining how it was being used or why it was not part of the curricular offerings. Phoenix [7] has investigated the inclusion of GIS in international schools. Thus, there has yet to be a detailed investigation of GIS in the undergraduate curriculum.

The current project remedies that situation. It provides the first baseline assessment of GIS coverage across the undergraduate curriculum that explores not only the current state of GIS education within specific disciplines but also attempts to determine impediments to its inclusion.

METHODOLOGY

Building on our pilot study with marketing professors [1], this one will also involve an online survey, with an email invitation to participate being sent to a random sample of faculty members teaching in four-year US universities in Criminal Justice, Environmental Science, Marketing, and Public Health. The long-term goal of this project is to expand the survey to incorporate additional areas such as Anthropology, Architecture, Civil Engineering, Real Estate, Sociology, and Urban Planning.

In order to build a questionnaire that would be relevant to the different disciplines, we are contacting faculty in these other fields for input about the ways in which GIS is used in each faculty member's respective field, how GIS is approached in the primary texts, how knowledgeable their fellow faculty members are likely to be about GIS, and what the relevant key words and phrases are that would be associated with GIS and its use in their field. Based on these conversations, we are incorporating their information and suggestions into the survey that we used in the pilot study. This revised questionnaire also is informed by the types of questions and issues addressed by the surveys identified above.

In addition to discipline-specific questions, everyone will be asked about the following issues, so that we can assess the "state of GIS" across the undergraduate curriculum, regardless of discipline.

- At what level faculty are knowledgeable about GIS.
- Whether faculty incorporate GIS into their classes, and at what level (discussion, hands-on assignments, labs, entire courses).
- Whether faculty use GIS as an analysis tool.
- The kinds of problems that faculty use GIS to solve (use of spatial statistics, network problems, and the like).

If faculty do not teach GIS in their curriculum, they will be asked questions such as the following, so that we can identify impediments to the implementation of GIS in the undergraduate curriculum. As noted earlier, the professional use of GIS is growing very rapidly and undergrads are being poorly served if they are not being introduced to the use of spatial analysis as an input to decision making.

- Whether GIS could play a role in their discipline.
- Whether GIS could play a role in their curriculum
- What might that role be (discussion, assignments, labs, courses).
- What the impediments to the inclusion of GIS are.

The initial survey has been approved by the RWU Human Subjects Review Board. Conversations with "subject experts" are on-going. We are learning that trying to cover all relevant disciplines in one survey may very well be quite difficult. Thus, we are considering a three-tiered approach in which an initial survey would be sent to faculty in three or four disciplines. While that survey is in the field, we would continue conversations with expert faculty in three or so areas and then field that survey. A final round of conversations and surveying would complete the survey of the desired disciplines.

CONCLUSION

After all the data have been gathered, it will be analyzed both within disciplines and across disciplines.

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DESIGN A COURSE MANAGEMENT SYSTEM FOR CONTENT SHARING, QUALITY CONTROL, AND CREATIVE INCENTIVE[1]

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ABSTRACT

Course Management System (CMS) supports teaching and learning through software tools and digital contents. CMS is broadly deployed but under-used due to the shortcomings of the extant systems. Majority of CMS provide tools but no contents and no mechanism to share contents. Some CMS emphasize contents but do not provide much tool's support. A few systems provide both tools and contents but lack built-in mechanisms to control quality and provide incentives to create or acquire quality contents. This paper describes a design of CMS which combines tools and contents, includes built-in mechanisms for quality control and incentives for creating and acquiring quality contents.

INTRODUCTION

Course Management System (CMS) is a mission-critical computer application in educational institutions. Teaching and learning, as information processes, can be supported by information technology through both software tools and digital contents. Most educational institutions have invested in CMS. In 2003, 80% of U.S. universities and colleges have deployed CMS (Morgan et al., 2003).

Significant costs are incurred by educational institutions to deploy CMS. The cost of implementing and updating CMS is reportedly in the order of millions of dollars (Sausner, 2005). After implementation, institutions continue to pay license and maintenance costs. Such costs range from several to tens of dollars per student per course. In addition, institutions incur costs in training faculty and students to use the systems.

However, CMS is under-used and under-valued by faculty and students. In 2005, only about 50% of faculty members are using the technology even in the most technologically advanced institutions (Sausner, 2005). Studies also found no evidence that utilizing CMS improves student learning or quality of teaching. Instead, the value of CMS is said to be mainly in the convenience it brings to students (Harrington et al., 2004; EDCAR, 2005).

There are reasons why CMS is under-used and under-valued. CMS systems fall into three categories: 1) CMS which provides software tools for teaching and learning but no educational contents. 2) CMS which provides contents but no software tools; 3) CMS which provide both software tools and contents.

Majority of extant CMS systems are purely software tools and do not provide content. They include majority of the commercial and open-source systems. Examples of purely tool-oriented *commercial* CMS include IBM Lotus Learning Space, WebCT, Intralearn, LearnLinc, BlackBoard, Centra, TopClass, SwitchPort, and Ecollege. Examples of purely tool-oriented *open-source* CMS include ATutor, Dokeos, dotLRN, ILIAS, Moodle, OpenUSS, Sakai, and Docebo. These tools have three main

[1] NEDSI Annual Meeting, Baltimore, MD, March 28-30, 2007

functionalities. 1) They provide tools for teachers to create and manage teaching materials; 2) they let teachers to distribute course materials and let students to submit homework over the Web; and they allow teachers and students to communicate; 3) they provide tools for teachers to test students and students to evaluate instructors. These functions reduce paper-cost, promote communication, and save instructors time. Such systems do not provide contents. Contents are to be created or imported to the system to be used by instructors and students.

Second, there are CMS systems which provide contents but lack tools to use them. For example, MIT Open Course Ware (OCW) publishes syllabi, lecture notes, course calendars, problem sets and solutions, exams, reading lists, etc., of 1400 courses from MIT on the Web. Safari Books Online publishes over 3,700 books on the Web. They provide web access to the educational materials but not many tools to use the contents in teaching and learning.

Third, there are a few systems which provide both software tools and digital contents. The contents in these systems are sharable and reusable by instructors and students within and across institutions. For example, Connexions include software tools and a library of contents. The software is open-source. It is developed at Rice University and based on the content management system, Plone, and on the application server, Zope. Both Plobe and Zope are open source software. The contents are contributed by users, typically instructors who use the system. The contents are distributed under the Creative Commons Attribution License (CCAL). CCAL allows any user to read contents and use them to create further contents. It requires users to acknowledge the authorship of used contents in the derivative contents. Currently, Connexions claims 3545 modules of contents, 183 courses, and one million users from 157 countries.

LON-CAPA is another example. LON-CAPA provides a content repository and a set of tools to create, assemble, and use the contents. LON-CAPA is used by member institutions, which currently include 37 universities, 4 community colleges, and 47 middle and high schools. It contains about 250,000 resources (images, problems, Web pages, animations and simulations, movies, and sound, and other files). 36% of the resources are considered in active use. The resources are shared among the member organizations.

However, current systems in the third category lack mechanisms providing incentive for users to create and contribute quality contents into the systems. For example, Connexions lacks such incentive mechanism due to the CCAL used to cover its contents. First, CCAL provides no commercial incentive to contribute quality contents; second, attribution of authorship required by CCAL for using teaching materials provides an intellectual prestige, which is generally considered less prestigious than attribution in research papers. In addition, there is no mechanism for quality control for the content in Connexions.

In the case of LON-CAPA, financial incentive in the form of royalty is mentioned. However, its importance is not sufficiently recognized in implementation. The mechanism of quality control in LON-CAPA is through membership of the institutions. However, membership is a crude and indirect way of quality control. It also limits the extent of content sharing. In addition, in both cases, the way in which the contents are organized makes it difficult to locate and share the contents.

The lack of incentive for content contribution and mechanism for quality control lead to a lack of quality content in the systems and limit the values of the systems.

This paper describes a CMS design which aims to overcome the shortcomings of extant CMS systems. The described design combines both software tools and digital contents. It includes mechanism of quality control through peer review. Contributed contents are eligible for peer review in the system. Contents passed peer review are marked so and promoted for use in teaching and learning and in creating derivative contents. Most importantly, the design includes incentive for contributing quality content into the system. Contributors are paid by users, primarily students using their contents. Essentially, the system provides a marketplace of educational contents.

THE DESIGN

Design Principles

The main design principles of the system are as follows:

1. User centered: design the system for teachers and others to create and distribute teaching materials and for teachers and students to use the materials in teaching and learning;
2. Combining contents and software tools: teaching and learning are supported by both contents and tools. Tools support the process of teaching and learning in a large part through manipulating the contents.
3. Design according to the teaching and learning process: For example, the process of teaching and learning includes teachers' authoring and presenting teaching materials, assessing student performance; students' browsing and studying materials, making notes, asking questions, and discussing issues. Tools for authoring, presentation, communication, note-taking, assessment, and evaluation should be built-in and activated at the moment when they are needed in the teaching and learning process.
4. Design for sharing and collaboration: Many tool-oriented CMS are designed for individual instructors without built-in support for sharing contents and collaboration among the instructors. This is in contrast to the fact that the same course is often taught by many instructors within and across institutions. A large portion of the materials of the course can be shared by a large number of instructors. Design should make it easy for instructors to share contents within and across institutions.
5. Design for quality control: Design for sharing leads to the need for quality control of contents. High quality contents are needed for effective teaching and learning. On the other side, a plague of low quality contents would make it difficult to find quality content and reduce the value of CMS. Therefore, quality control is critical. A simple mechanism for quality control is peer review. Content submitted to the system is made available for peer review; contents passed peer review are marked so and promoted for possible use by other instructors. Contents which have not passed peer reviews are marked as such.
6. Design for incentive of contributing quality content: The quality of content in the system ultimately depends on the incentives of its users and others to contribute quality contents. There are various possible incentives for contributing quality content. Examples include peer recognition, the fun of creating the contents, and the joy of helping others and a community. The system should support and utilize these possible incentives. Furthermore, the system should utilize commercial incentive. The design should allow contributors to set prices of their contents and be paid by users of the contents. The system should provide a marketplace for teaching materials. It can be thought an online version of the market of textbooks, only extended by other kinds of teaching materials and by software tools.

The Design

The design includes a set of use cases for authoring, teaching, learning, and billing. A set of tools is designed to realize the uses cases. The tools sit on top of and utilize the infrastructure of web server, web browser, application servers, and database. The database contains contents encoded in a special XML format, called CMSXML. The details of the design are as follows.

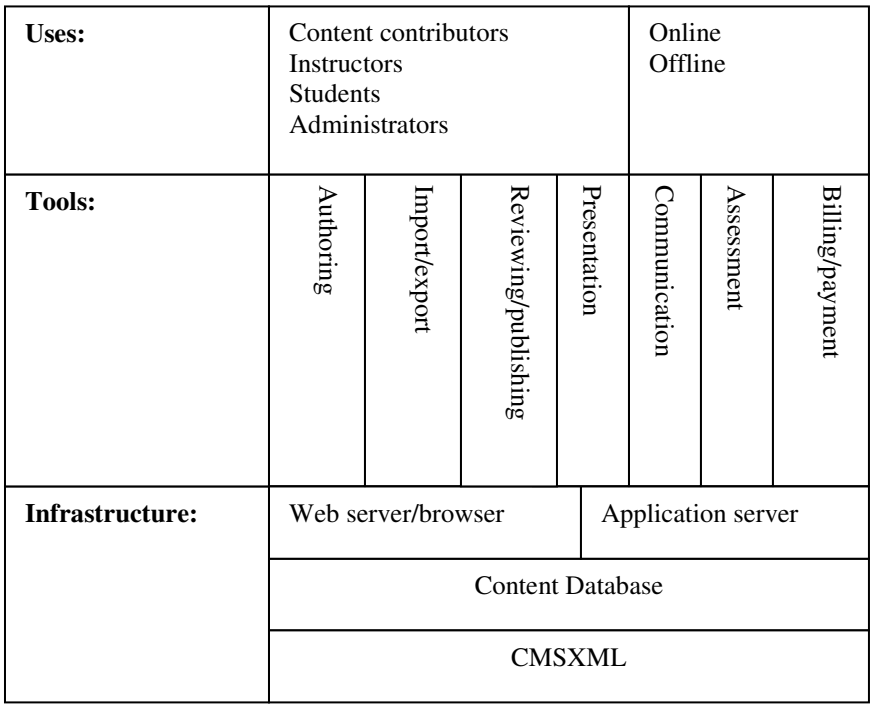
1. Use cases: They include:
    a. authors create contents, search and browse contents, and use contents to create new contents in the CMS, import and convert contents created elsewhere; reviewers review contents; authors responds to reviewers' comments and revise contents; administrators publish contents;
    b. instructors select contents to be used in classes, use contents in teaching; instructors export or print contents for offline uses;
    c. students study contents and take notes; students export or print contents for offline uses; students ask questions; teachers and TAs answer questions; students and teachers discuss issues;
    d. instructors assign homework; students finish or submit finished homework; teachers or TAs grade homework;
    e. teachers administrate tests; students take tests; teachers and TA grade test; teachers and students review tests;
    f. CMS bill students for use of system and contents; authors are paid by the CMS for usage of their contents by students.

2. Content format: Contents in the CMS include contents created with tools within the CMS and those created outside and imported into the system. The contents may be articles, books, web pages, slides, questions, tests, syllabus, text, lectures, audio, video, etc. The contents should be as machine-readable as possible. To this end, an XML-based format should be created and used to mark or tag all contents.

3. Tools: They include:
    a. authoring tools to create or compose slides, articles, papers, and books, question sets, exams, and syllabi; tools to capture, edit, and upload audio and video;
    b. tools for presentation and browse of slides and web pages;
    c. tools for communication between and among instructors and students;
    d. tools for import, export, and convert contents for online and offline uses;
    e. tools for administrating, taking, and grading tests and quizzes;
    f. tools to bill students and pay authors and other content contributors.

The design is summarized in the following diagram.

Figure 1: Architecture of Proposed CMS



CONCLUSION

Teaching and learning are increasingly important activities in the growingly knowledge-based economy. Teaching and learning are an information process ideally suitable for support by information technology. CMS is mission critical and widely deployed in high educational institutions. However, it is currently under-utilized and under-valued. The low valuation of CMS is due to the separation of tools and contents in majority of the current CMS systems, the insufficient mechanism for quality control, and the lack of effective incentive mechanism to create and acquire high quality contents in the current CMS systems. We described the high-level design of a CMS to overcome these shortcomings of current CMS systems. Important features of the design include the combination of software tools and contents, the sharing of contents among content contributors and instructors and across institutions, the market mechanism to encourage contributing quality contents, and the quality control mechanism through peer review.

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CYBER PREDATION OF CHILDREN: TECHNOLOGY-ENABLED TEMPTATION

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ABSTRACT

Computers and technological device use has increased steadily over time since the inception of computational technology. Today, individuals describe having social relationships with their technological devices (Bickmore & Picard, 2005). These social relationships—much like relationships to pets, vehicles, etc.—require time and effort to maintain and more individuals are responding to technological devices in social ways (Reeves & Nass, 1996).

Increased social behavior that involves technology as a medium, actor, or conduit, directly push a much wider portion of society into activities not normally traversed because barriers imposed by social mores are weakened.

Children, in particular, are extremely vulnerable as technology enables social interaction with both media and the world at large (Reeves & Nass, 1996). This paper examines predatory behaviors enabled by technology and provides a basis for additional research in this area.

INTRODUCTION

Predators have long existed in society but were typically limited by physical boundaries, whether it be social, ethical, or moral means. The threat of exposure and punishment precludes action on the part of individuals defined as "pre-conventional" by Kohlberg (1958, 1976) thus creating some level of physical protection. The Internet and the idea of the computer as a social "partner" enables action on the part of Kohlbergian pre-conventionalists from which they would otherwise abstain. Likewise, we see increasing amounts of predation involving computer use as a conduit that enables the anonymous exploitation of children. Anecdotes and media reports abound of sexual predators using the Internet to contact and lure children and teens for sexual exploitation (Associated Press, 2006; Clark, 2006; Freeman, 2006), yet there remains very little empirical research on the subject (Potter & Potter, 2001).

In 1999, the National Center for Missing and Exploited Children identified 785 cases in which a child or adult traveled to physically meet with someone they had initially encountered on the Internet (Potter & Potter, 2001). This alone provides evidence that the initial computer as a social partner stage often enables the predator to move to the next stage and attempt physical contact. Thus the technology medium may short circuit the pre-conventionalists fear of punishment and retribution and allows physical relationships to supersede virtual relationships.

As with all crime, child predation on the Internet has three requirements: a motivated offender, a suitable target, and the lack of a suitable guardian (Cohen and Felson, 1979). The purpose of this paper is to explore each segment to see how it is met and to study the implications and actions needed to stop this behavior.

CYBERPREDATION TYPOLOGIES

Many papers have explored criminal motivations with a focus on various areas of criminal activity (Clark and Ecke, 2003; Clark and Felson, 1993; Cohen and Felson, 1979; Felson, 1997; Felson, 1998, Felson and Clark, 1998). Demonstration of motivation alone may result in a conviction of the offender. With more "normal" crimes like assault, breaking and entering, and larceny, the motivation behind the crime is usually fairly easy to discern. When it comes to crimes like sexual predation and assault, the motivations behind the offense tends to be more psychologically entrenched and difficult to discern. According to Lamb (in Quayle and Taylor, 2001), online sexual predators come in three categories: browsers, cruisers, and pornographers.

Browsers

Browsers are generally curious people exploring the Internet and interested in meeting real people. Their language and knowledge of sexual experiences is very adolescent and conversations rarely diverge into personal or sexual information. A study by Quayle and Taylor (2001) demonstrated that browsers are also the smallest represented group of Internet predators. Browsers exhibit social behavior where the computer is being used as a conduit to social activity or as a social partner. This type of behavior is facilitated by the "short-circuit" of the pre-conventional model since the browser who might never explore a schoolyard or approach a child in an attempt to engage the child in any behavior may be exposed to children in the process of visiting "adult sites."

Pornographers

Pornographers are highly skilled users of the Internet, who reveal very little information about themselves, and focus more on the trading of pornographic photographs (Quayle & Taylor, 2001). These individuals drive the exploitation industry and encourage the development of resources that will produce additional photographs. Again, the pre-conventional "short-circuit" is enabled by the social actor of the computer as the conduit that allows anonymous activity that might otherwise not take place.

Cruisers

The largest represented group, known as the cruisers, typically represented themselves as students of alternative cultures out to explore new experiences. Cruisers do have an extensive knowledge of gay and straight sexual practices and focus on talking about their own experiences or about their fantasies. Many cruisers also look for contact outside of chat rooms (Quayle & Taylor, 2001).

CyberPredator Motivation

Still, what aspects differentiate between a browser and a cruiser? What separates a person looking at legal pornography from one looking at child pornography? And what makes the one looking at child pornography delve into the realms of child predation? According to Quayle & Taylor (2003), offender differences in empathy, social skills, and cognitive processes separate the offenders: "Distortions in the way sex offenders think are assumed to reflect attitudes and beliefs which are used to deny, minimize, and rationalize behavior , related to underlying belief systems or schema which play a role in precipitating and maintaining offending" (Quayle & Taylor 2003, 93).

Also, sex offenders have the inability to infer mental states and often target children they perceive as vulnerable in order to groom the child into what the offender believes the child should be, thereby increasing the opportunity of offending (Quayle & Taylor, 2003). In other words, sex offenders lack

the understanding that people typically have in the world. Like other criminals, they rationalize their actions and tend to target victims with the same views as their own or who are seen as vulnerable.

PROFILING CYBER- PREDATORS AND VICTIMS

A major study conducted by Quayle & Taylor analyzes data from the COPINE project at the University College Cork, Ireland. The COPINE project is an interview series of offenders convicted of downloading child pornography in order to better understand why the offenders engaged in such behavior. For the purpose of their research, Quayle & Taylor analyze the interviews of 23 men, all convicted of various child pornography offenses. Twenty of these men traded pornography, eight produced child pornography, and eleven committed a contact offense against children.

From Explorer to Exploiter

Results of these interviews provide some valuable information regarding the profile of a child predator and reason behind their use of the Internet. According to Quayle & Taylor (2003), the interviewees suffered from both distal—early-sexualized experiences and poor adolescent socialization skills—and proximal—commission of prior sex offenses or dissatisfaction with their current self—setting events that helped aid in the decision to use the Internet as means of predation. Most child predators tend to have long-lasting difficulties forming relationships and relating with adults, but can relate to children. To avoid potential social stigma, these individuals tend to gravitate towards the Internet.

What starts out as "innocent use" of the Internet quickly turns into an obsession. It is important to note that, like most sex offenders, online child predators did not necessarily start out with the intention of becoming predators. Rather, there appears to be a progression from one level to the next, based upon the need and fantasies of the user. As these individuals start to download and trade pornographic images with other people having the same interests, the process quickly becomes normalized giving the individual a sense of community they would not normally be able to find elsewhere (Quayle & Taylor, 2003). In order to actual find others to trade with, users must establish credibility, usually through the size and content of their pornographic collection. The more credibility one has, the more attention and action they will receive.

Illicit Interaction

After the downloading and trading of illegal pornographic images, the next step involves the acting out of their fantasies. "Collecting pictures from the Internet led to an increase in both fantasy and sexual activity" (Quayle & Taylor 2003, 100). This step usually involves the use of sexual chat rooms where many predators will adopt false personas or even a child persona in order to act out their sexual fantasies and interact with the legitimate users of the chat room. These nicknames provide the users with a way to express parts of themselves that they would not be able to express elsewhere and allow them to be themselves without giving up their real identities.

Again, the process whereby the pre-conventionalist would normally "stop" the activity for fear of punishment has been short circuited by the social agent of technology. Chatting to others in the guise of a child allows the user to justify his/her behavior by believing that the conversations were between two children instead of a child and an adult and continue to act anonymously with little fear of punishment and exposure. The normalization of these relationships was very important to the users. In order to achieve this goal, users often will send gifts to their target and can range anywhere from money to flowers. Users quite often will "marry" their target within the chat room and continue the

relationship that way (Quayle & Taylor, 2001). Ironically, in many cases, both users are disguising themselves as children, therefore having two adults in the relationship and destroying the fantasy.

Catalyst for Typology Transformation

As with all sex offenders, the need for power and control is what separates the browsers and pornographers from the cruisers. There is an increase in feelings of power associated with being able to obtain the child pornography, build up a collection, and gain credibility with other users. This notion of control permeated into the chat rooms as well. When the fantasies increase, predators drop the child persona and assume an adult persona identical to their own. Self-representing as an adult male allows the predator to chat with children, engage in sexual activity through the Internet and telephone, and arrange meetings. Predators will legitimize this behavior because it is an extension of the behaviors that went on willingly in the chat rooms. Predators, caught up in the fantasy of it all, believe that this meeting is an extension of the online relationship and therefore is acceptable.

Profile of A Cyber Victim

In order for a sexual predator to be successful, there must be a victim. Usually, victims of crimes have certain aspects to their personalities that make them more susceptible to a particular offense. This model holds true in the online predation of children as well. Interestingly, the same aspects that are seen within the profile of a cyber predator are also seen in the profile of their victims. Children who have difficulties with face-to-face relationships generally find it easier to express themselves and find community on the Internet. It becomes the only place where they can be accepted for who they are.

Since the Internet bases communication solely on text, it is easy for teenagers to get caught up in the false promises given out by predators: "The absence of physical, verbal, and non-verbal cues may make it difficult for some teens to know if a message is truthful, sincere, relevant, and accurate. It is the absence of this information that allows some individuals to be dangerous predators to meet, manipulate, and potentially seduce their victims" (Sanger, et.al 2004, 126-127). Juveniles may be well educated in not giving out sensitive information to strangers in person, but many are prepared to do so when gifts or promises of gifts are offered in chat rooms (Fleming & Rickwood, 2004). Many predators look for the type of juvenile whom is depressed, troubled, and has poor social skills because that is the type of person the predator is and feels most comfortable with.

INTERNET AS PREDATORY VEHICLE

Arguably, the largest reason why child predators are so prevalent is the Internet itself. "Every conceivable form of dangerous information, activity, and persons found in society might also be found in cyberspace" (Potter & Potter, 2001). Although usernames are required for e-mail and access to many Websites, identities are fluid and changing. Personas and monikers are the norm. Moreover, with the power of search engine technology, the Internet has become an anonymous tool for individuals to privately and secretly research any topic. Both the anonymity and the playful quality of the Internet have a disinhibiting effect on behavior. People are more likely to allow themselves to behave differently from everyday life and to express other aspects of their personality (Quayle & Taylor, 2001).

Anonymity and Lack of Regulation

Anonymity provides a perfect medium for sexual predators and even facilitates the behavior. For them, the Internet provides a means for sexual exploration that involves little or no actual contact

with people. Add in the fact that the desired material and conversations are readily available along with others with the same interests and the Internet becomes a little private community for the predator.

Also helpful to the continued "success" of online predators is the ever-growing grey area of Internet regulations. Initially, the Internet was intended as a "marketplace of ideas" where anyone can share their beliefs with little to no government regulations. Currently, Internet regulations are still very scarce. Very few topics, like child pornography, are illegal or restricted by a particular law given the Internet's international boundaries. Even though the trading, downloading, or production of child pornographic images is illegal, the sexualized talking and engaging in online sexual role-plays are not necessarily illegal (Quayle & Taylor, 2003). This legal grey area further normalizes the behavior of the sexual predator and facilitates them into committing an actual contact offense. Due to the difficulty of regulating or policing Internet use, child sexual predators are usually caught in a reactive fashion.

MySpace As Microcosm

An example of this can be seen with the popular online community MySpace.com. Much negative attention has been directed at MySpace for all the reported child sexual assaults that have originated between a predator and a teenager meeting on MySpace. This behavior is not novel. When America Online first introduced its chat room feature, it received the same negative attention. In fact, MySpace has many rules in place to help protect the user. MySpace does not allow anyone under the age of fourteen to keep a profile and security measures are in place to privatize the profiles of anyone aged fourteen to sixteen (Associated Press, 2006).

As with all social networking sites, MySpace encourages users not to post or share personal information about themselves. Of course, some people lie about themselves and MySpace has a function that browses every profile and deletes the ones that seem to be false. Unfortunately, not everything can be caught. The Wisconsin Department of Corrections recently found at least two dozen people who have MySpace profiles that match information in the state sex offender registry (Epstein, 2006). These individuals were not initially found for two reasons: they adopted a nickname and personality not resembling their original self and posting a profile on MySpace is not an illegal action so it was not monitored. The only legal action that can be taken against these individuals is to have probation and parole officers do more frequent checks on the individual (Epstein, 2006).

Policing in CyberSpace

Although the anonymity, secrecy, and the lack of regulations on the Internet help facilitate child predators, it is now also being used to investigate and apprehend them. Many state police agencies, along with the FBI, will make profiles or pose as young children in order to lure cyberpredators into a physical meeting. Officers will take on the persona of a young child and engage a predator into conversation for a varying length of time. During the initial conversation phase, the goal is to get the predator to trade illegal pornographic images and to also procure as much information about the predator as possible. An in person meeting is then set up with the predator at a pre-determined location. The "child" obviously will not show up, but the police monitor the location in order to ensure the arrival of the predator. More conversation with the predator will happen online and another in person meeting will be set up. At this next meeting, the predator is usually arrested (Federal Bureau of Investigations, 2006).

This type of police work is so popular that the United Kingdom has recently started a 24-hour crime unit called the Child Exploitation and Online Protection Centre, whose sole purpose is to investigate

claims of online child predation (BBC News, 2006). The agency, whose aim is to make the UK the safest place for children to use the Internet, operates mainly on claims from concerned parents and children. In addition, the agency blocks and documents the trading of child pornography, poses as children in order to lure predators, and sets up fake child porn websites in order to lure predators and gain their personal information including name, address and credit card number (BBC News, 2006). Since there are very few laws regarding Internet use, police officers are allowed to take on the persona of a child in order to lure predators without the fear of an entrapment argument.

CONCLUSION

Internet predators of children are typically individuals who have poor adult relationships and social skills and also have psychological limitations that make them identify more with teenagers and adolescents. Since it is frowned upon for adults to have any type of relationship with children, these people gravitate towards the Internet in order to fulfill their desires. Initially, predators are interested in the downloading and trading of child pornography, but the desire soon turns into sexual chatting with children. Predators typically groom children that are like themselves and lack the social skills to have proper personal relationships. Eventually the predator will attempt to arrange an in person meeting in hopes of physically acting out their sexual fantasies. Because the Internet is based on the aspects of anonymity and secrecy, it is difficult to stop the sexual assault before it happens. Besides the actual trading of pornography, little of what a predator does online is illegal. To combat this, police agencies setup fake websites and pose as children in order to lure predators into arrest.

The Internet facilitates the progression from browser to cruiser. This type of progression is greatly enabled by the computer used as a social agent of social conduit that may short-circuit the Pre-conventional fears that would otherwise prevent the behavior. The continued proliferation of the Internet and the popularity of sites such as MySpace, youTube, and other sites where personal involvement via the technological conduit replaces personal interaction will continue to encourage the obsession and progression of offenders into the act of physical encounters with children.

FUTURE RESEARCH

This paper provides a platform for the development of additional research into the means of creating a method to enact the same fear of punishment and retribution which exists in the physical world and thusly evokes the Kohlbergian behavior of avoidance on the virtual realities of the Internet. Parents must act to intervene in the removal of the component of “lack of guardian” as well as education on this matter. The rise of sites that expose predators is also a means to facilitate this.

The need for more comprehensive research to identify predatory behavior and means of interruption of this process is strong as is evidenced in this examination of literature and behavioral norms. The need to explore Kohlberg’s ideas when technology acts as a social enabler is also critical to the further understanding of means to prevent online predation.

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ADOPTION INHIBITORS AND FACILITATORS OF EMERGENCY RESPONSE INFORMATION SYSTEMS (ERIS)

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ABSTRACT

The need for Emergency Response Information Systems (ERIS) has increased in the recent past due to tragic events such as the World Trade Center disaster and hurricane Katrina. In 2004, the federal government developed the National Incident Management System (NIMS), and subsequently mandated NIMS compliance for all entities associated with disaster management. In this research-in-progress, we outline the emergence of ERIS and examine the progress that local governments and municipalities are making in terms of becoming NIMS compliant. We examine social, technical, and economic factors that serve to either inhibit or facilitate the adoption of ERIS in the public sector.

KEYWORDS

Emergency response information system, technology adoption

OVERVIEW

Since the events of September 11, 2001, the emphasis on emergency management has received considerable attention. More recently, failures due to the lack of communication and information sharing during the response to hurricanes Katrina and Rita has led to a broad rethinking of emergency management. In particular, the response to Katrina illuminated a pronounced information asymmetry between the city of New Orleans, the state of Louisiana, and the federal government. In fact, these events along with the advances in Internet technologies have ushered in a transformation of the emergency management activity. As a result, we are now witnessing the evolution of emergency response information systems (ERIS).

In 2004, the federal government developed the National Incident Management System – NIMS. As a result, municipalities and local governments are now required to be NIMS compliant. With NIMS compliance state and local agencies would: 1.use common

incident management products and methods; 2.integrate response units across different jurisdictions; 3.order and track response assets and 4.establish effective communication mechanisms (http://www.fema.gov/emergency/nims/index.shtm).

Information Systems, by definition are socio-technical systems. This bi-modal nature of information systems is particularly relevant for systems that are initiated in response to natural or man-made disasters. The use of ERIS occurs under a unique and unfortunate set of conditions that is atypical in a business environment. Consequently, social, technical, and economic factors affect the implementation and adoption of such systems.

In this paper we present a theoretical model for the examination of ERIS. The constructs presented will then be tested in the public sector domain – specifically local government municipalities. The next section of the paper defines ERIS and examines factors affecting their adoption. Following this we present our methodology and proposed constructs for the study. We conclude the paper with a summary of the ideas presented.

EMERGENCY RESPONSE INFORMATION SYSTEMS (ERIS)

ERIS support emergency management by providing a set of tools for planning, assessment, and decision making during the critical period. The 911 system, first implemented in Haleyville, AL [1] is a primary pre-cursor to the implementation of more complex systems. The efficiency of a disaster response is affected by the disaster severity, response strategies, available resources, and number of jurisdictions involved [2]. An effective ERIS provides a comprehensive framework of relevant tools and information to response teams.

Disasters can result in the collapse of a region's technical, social, and economic infrastructure and cascade into other unexpected domains [2]. As a result of the far reaching impact, multiple factors contribute to the adoption of such systems. Local municipalities with limited resources and staff may be unable to effectively implement such critical systems. Technical, social and economic factors can inhibit the adoption and implementation of such systems.

Adoption Framework

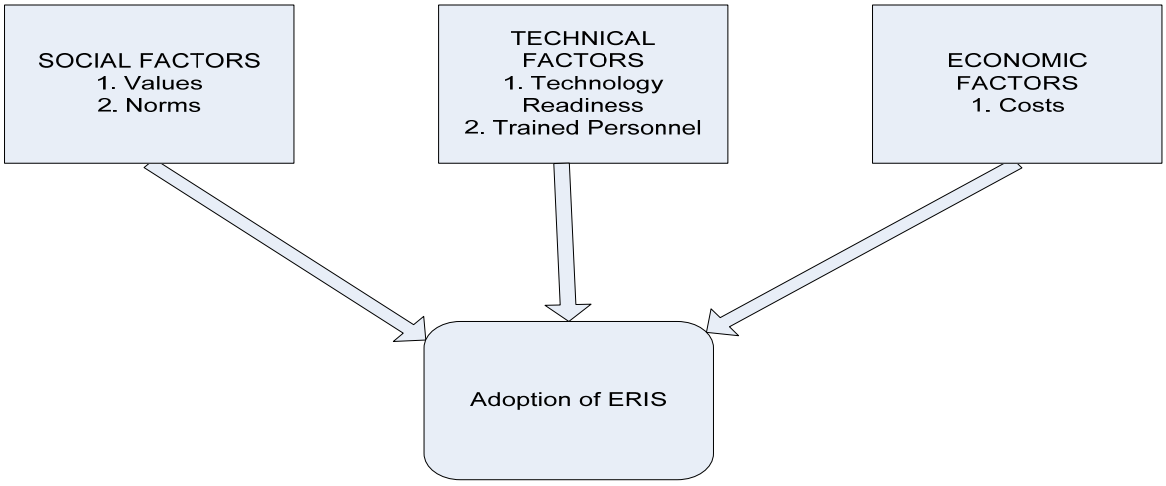
Several models including: technology acceptance model [3-5], perceived characteristics of an innovation [6] and innovation diffusion theory [7]; have been examined in the information systems literature to better explain the technology adoption phenomenon.

The application of ERIS in the local government sector presents a unique combination of technical, social, and economic variables that can account for adoption behaviors. The technical factor includes the availability of the relevant information technology (IT) infrastructure. The IT infrastructure can range from the presence of dial-up internet connection to broadband and/or wireless capabilities. The level of IT available in the local municipality is collectively referred to as its technology readiness. The second component under the technology umbrella is the presence of skilled personnel. With the

implementation of any information systems, the presence of well-trained staff can serve as a key catalyst for adoption.

Values and norms define the social fabric of an organization. The perceived usefulness of a technology [3] and the individual's intention to use [8] are strongly correlated with the user's eventual behavior patterns. However if there is a dominant culture unwillingly to engage in technology use, an individual's willingness to use the technology will not necessarily translate to adoption. Ultimately, we propose that larger organizational norms will have a greater influence on adoption of ERIS than individual characteristics. The third component affecting the adoption of ERIS is economic. NIMS compliance outlines a set of guidelines to follow. However, available funding for such projects might prove to be an insurmountable barrier for small local municipalities. Figure 1 summarizes the factors affecting the adoption of ERIS by local governments.

Figure 1: Factors Affecting the Adoption of ERIS



METHODOLOGY

To examine the proposed constructs both a qualitative and a quantitative approach is necessary. We do so by analyzing the adoption behaviors of local governments in a Northeast State that consist of 67 counties and 2565 local municipalities. The data for this study will be conducted in two phases. Phase 1 of the study involves conducting semi-structured interviews to determine if there are other factors affecting the adoption of ERIS in the local governments that were not revealed during our review of the existing literature. The target participants for this initial phase of data collection will be administrators from local municipalities.

Phase 2 of the study requires the distribution of surveys to the 2565 local municipalities in the state. The survey questions will be derived from findings in the extant literature as well as additional concepts that are revealed during data collection from phase 1. Regression analysis will then be used for analysis of the data.

CONCLUSION

This paper reports on the elementary stages of a study to examine the adoption of emergency response information systems (ERIS) in local governments. Technical, social, and economic factors provide the basis for analyzing the adoption phenomenon. Emergency management is of crucial importance today, given recent natural disasters and the war against terrorism. Examination of this issue is relevant from both a researcher and practitioner perspective. More importantly, the outcome of such studies can have far reaching consequences as cities and nations prepare for disasters.

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Risk Management, Capital Management, and Financial Management for Insurance Industry : An Application of Structural Equation Modeling*

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Introduction

Risk management of an insurance firm is to control risk and keep the risk at an acceptable and controllable level. Nevertheless, as a profit-seeking company, an insurance firm should achieve the goal of firm-value maximization. Obviously, there exists a firm-value and investment-risk trade off between the goal of risk management and that of financial management. In addition, capital management plays an important role in the management of financial institutions. While a financial managerial decision is to increase cash flows at a given level of risk, capital management focuses on the dynamics of transactions of financial instruments and liquidity. Therefore, it is difficult to integrate the decision making for these three different management philosophies.

Literature has discussed the links among the three managements (e.g., Froot, Scharfstein, and Stein, 1993; Cebenoyan and Strahan, 2004; Shimpi, 2002; Froot and Stein, 1998; and Leland, 1998). Some studies have explored these three managements for the banking industry (e.g., Cebenoyan and Strahan, 2004; and Daníelsson, Jorgensen, and Vries, 2002). Nevertheless, a thorough empirical study on the integration of these three managements is few, needless to say any empirics on the time-varying patterns of the insurance companies. Since an empirical model integrating risk management, capital management and financial management is not available, a statistical model is chosen to depict the numerical relationship among them. Structural Equation Modeling (SEM) is a model often used to explore such relationship among unknown latent variables. And here, we used three different latent variables to describe the decision making of risk management, capital management and financial management.

Structural Equation Modeling

Structuring Equation Modeling defines the causality among risk management, capital management, and financial management. The causality relationships are represented by β_{12}, β_{21}, β_{23}, β_{32}, β_{13}, and β_{31}. Y_1, Y_2, …, Y_8 denote the observed indicator variables for the risk management, capital management, and financial management, which are defined as latent variables η_1, η_2, and η_3, respectively. Measurement errors ε_s (s = 1, 2,…,8) for each observed variable are incorporated in Figure 3. Therefore, a measurement equations are denoted as matrix below:

$$\begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \\ Y_5 \\ Y_6 \\ Y_7 \\ Y_8 \end{bmatrix} = \begin{bmatrix} \lambda_{11} & 0 & 0 \\ \lambda_{21} & 0 & 0 \\ \lambda_{31} & 0 & 0 \\ \lambda_{41} & \lambda_{42} & 0 \\ 0 & \lambda_{52} & 0 \\ \lambda_{61} & \lambda_{62} & \lambda_{63} \\ 0 & \lambda_{72} & \lambda_{73} \\ \lambda_{81} & \lambda_{82} & \lambda_{83} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \end{bmatrix}$$

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The coefficient matrix determines the structure of a particular path analytical model by considering the interrelationship among ç1, ç2, and ç3. å1, å2… and å8 are the error terms associated with endogenous variables Y_1, Y_2…and Y_8, respectively.

A *prior* hypothesized structure assumes that the asset risk and liability risk levels and the regulatory requirement are the central focus and common factors underlying the three managerial decisions. In addition, different from the extant literature, in this research, not only asset risk, but also liability risk levels are used to represent the risk-taking behaviors of insurance companies. Thus,

$$\begin{bmatrix} h_1 \\ h_2 \\ h_3 \end{bmatrix} = \begin{bmatrix} 0 & b_{12} & b_{13} \\ b_{21} & 0 & b_{23} \\ b_{31} & b_{32} & 0 \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \\ h_3 \end{bmatrix} + \begin{bmatrix} g_1 \\ g_2 \\ g_3 \end{bmatrix} [x] + \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix}$$

The first-level structural equations are to indicate the essential factor that fundamentally drives the managerial decisions, and the second-level structural equations are to illustrate the interactions between the latent variables. Here, we can observe that the SEM helps construct the regulatory latent variable correspondingly, under which the managerial decisions' effects are reflected in the observed manifest variables. Through the interactions between latent variables in the first- and the second-level regression, the net effects are presented in the measurement equations.

Empirical Study

This paper takes *a prior* hypothesized structure to explain risk management, capital management, and financial management. In order to explicitly examine the hypothesized relations among the variables, we will conduct an empirical study by employing the data from the National Association of Insurance Commissioners (NAIC). Assets, liabilities, reinsurance premium, and exhibits of investment, to measure the financial management and capital management latent variables are culled from the NAIC regulatory statements. The sample period expands from year 2000 to 2002. A multi-year analysis helps further examine the time-varying patterns of the three managerial activities. Through a model-fit technique along with the implementation of empirical data analysis the hypothesized structure can be adjusted to reflect the most appropriate structural relationships between the latent and observed variables. That is, we can test whether or not that *a prior* hypothesized structure is appropriate by including or excluding some observed variables.

The Empirical Results of the Structural Equation Modeling

The empirical results of the SEM are listed in Table 2 and indicated in Figure 1. in Table 2, three levels of empirical results are presented in three Panels. Panel I shows parameter estimates of first-level structural regressions; Panel II is for parameter estimates of second-level structural regression; and Panel III estimates parameter of measurement equations regression.

Under the measurement equations framework as Figure 1 shows, we argue that the degrees of the use of reinsurance and financial derivatives are from the effects of an insurer risk management decision, which is assumed as an unobservable latent variable. Thus the observable manifest variables— reinsurance premium and transactions in financial derivatives are directly from the implied risk management strategies. Likewise, the unobservable capital management latent variable is assumed to have its direct effects on the growth in premium, asset allocation in bond, stocks, mortgage, and real estate, capital level, the ratio of policyholders' surplus to risk-based capital, the ratio of risk-based capital to regulatory capital level, and liability risks measured by the reserves level in long-tail insurance lines. The manifest variables of premium growth and asset allocation are directly linked to the financial management. Moreover, the effects of risk management, financial management, and capital management on the corresponding manifest variables are through the interactions between these three managerial decisions as well as the essential regulatory requirements. For example, the direct effects from risk management on the degree of the use of reinsurance and financial derivatives have taken into account the effects of regulations on the three managerial decisions and the interactions between them.

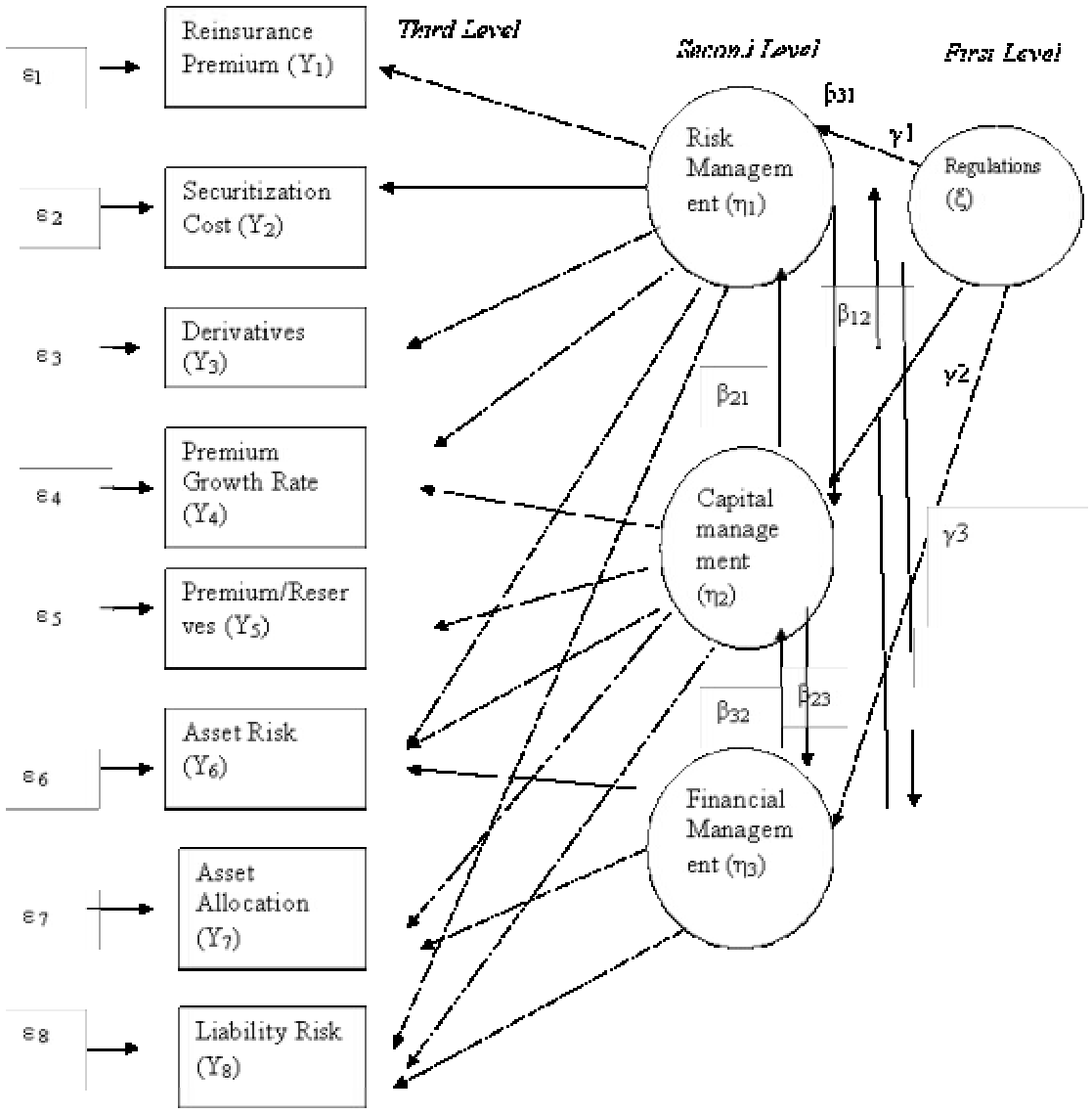

Figure 1 A Structural Equation Model of risk management, capital management, and financial management

Table 1 Summary of Statistics

Year	2000			2001			2002		
	mean	Std	Obs	mean	Std	Obs	mean	Std	Obs
RePrem	50,127,526	242,701,809	1072	48,603,573	233,458,501	1076	63,849,537	304,928,594	1043
Re_NPW	0.2955	0.2604	1072	0.3063	0.2680	1076	0.3148	0.2664	1043
Re_GPW	0.2163	0.1627	1072	0.2211	0.1615	1076	0.2271	0.1606	1043
T_Amount	8,530,010	401,255,958	1941	19,576,118	620,186,348	1962	(3,188,198)	301,947,858	1891
BdPct	0.6737	0.2577	1971	0.6702	0.2591	1971	0.6686	0.2532	1891
StkPct	0.1387	0.1749	1971	0.1341	0.1724	1971	0.1197	0.1585	1891
MgPct	0.0032	0.0275	1971	0.0030	0.0217	1971	0.0025	0.0186	1891
RePct	0.0117	0.0347	1971	0.0108	0.0304	1971	0.0111	0.0334	1891
NPW_Gw	4.9058	190.7484	1918	7.0182	131.0746	1971	1.7645	13.0534	1891
Cap_TA	0.4795	0.2190	1971	0.4485	0.3905	1971	0.4217	0.2214	1891
Sup_RBC	1.0154	0.3329	1837	0.9998	0.5905	1846	1.0055	0.3168	1772
RBC_Reg	24.7633	187.8682	1812	17.4278	66.6116	1825	17.6494	97.6270	1767
LgTail_L	0.1162	0.2194	1941	0.1107	0.2023	1960	0.1133	0.2456	1885
LR_Pro_L	0.0050	0.0223	1941	0.0044	0.0171	1960	0.0051	0.0222	1885
Re_NPW	0.3063	0.2680	1076	0.0209	0.8283	1884	-0.0181	0.8375	1981
Re_GPW	0.2211	0.1615	1076	0.0274	0.9313	1884	-0.0210	1.0111	1981

Legend:
RePrem: reinsurance premium written.
Re_NPW RePrem divided by Net Premium Written.
Re_GPW RePrem divided by Gross Premium Written.
BdPct: Asset investment in bond to total investment..
StkPct: Asset investment in stock to total investment..
MgPct: Asset investment in Mortgage of real estate to total investment..
RePct: Asset investment in real estate to total investment..
NPW_Gw: the growth rate of net premium written.
Cap_tA: ratio of capital to asset.
Sup_RBC: rati of policy holders' surplus to RBC.
RBC_Reg: regulatory constraint, whether RBC>=2.

Consistent with our expectations, the results suggest that the managerial decisions in risk management have positive effects on the use of reinsurance and financial derivatives to manage the insurers' underwriting risks as well as investment risks. Along with the results shown in structural regressions and the second level of structural equations in year 2000, such positive effects are from the negative relationship between capital management and risk management and positive relationship between risk management and financial management. In addition, a positive effect of the essential regulatory factor on risk management also contributes to the positive effects of risk managerial decision on the use of reinsurance and financial derivatives.

On the other hand, as shown in the results in Figure 4 of the first- and second-level regressions, in years 2001 and 2002, the effects of regulations on risk managerial decision strongly dominate the inter-effects from capital management and financial management. The interactions result in corresponding net positive effects on the degree of using financial derivatives and reinsurance. It is noteworthy that the magnitudes on the use of reinsurance maintain at a stable level, while the risk management triggered a larger magnitude of using financial derivatives in year 2001, and the level decreases in 2002.

As expected, regulations have positive effects on capital management that suggest that under a more stringent regulatory environment, insurers are more actively to engage in capital, financial, and risk managements. Such observations are consistent in the sample period from year 2000 to 2002. By examining the inter-effects from risk management and financial management on capital management, we find that a seemingly structural change occurs. Results show that in year 2000 a more active risk management and financial mismanagement will result in a more active capital management as well, however, the inter-effects became opposite in year 2001, and became insignificant in year 2002.
Such seemingly structural changes are also reflected in the net effects on the manifest observed variables of premium growth and asset risks between year 2000 and 2001.

In year 2000, capital management results in an aggressive underwriting business in terms of a higher magnitude of premium growth and a conservative investment strategies in allocating assets in bonds and stocks, while retains a higher level of capital to meet regulatory requirements. Through the dominating effects from regulations on capital management, the managerial strategies in underwriting risk as well as investment risks become more conservative in terms of the smaller magnitudes of coefficients on premium growth and asset allocations in bonds, and stocks. In addition, throughout the sample period 2000 to 2002, the negative coefficients on the liability risk variable measured by the ratio of the loss reserves of long-tail insurance lines to total liabilities suggest that the net effects from capital management on liability risk maintain a consistent and conservative level throughout the sample period.

Results from the first-level of structural equations in year 2000 show that regulations present a positive effect on financial management. On the other hand, the inter-relationships between financial management and capital management as well as risk management suggest an opposite direction meaning that a more active risk management and capital management results in a less active financial management. Such combined effects from the first- and second-level of structural equations cause positive responses in premium growth and asset allocation in bond and stock. However, in years 2001 and 2002, as the effects from regulations dominate the effects from capital and risk managements on financial management, a more conservative the premium growth and investment risk in terms of asset allocation prevails from the influences of financial management.

Conclusions

It is essential to investigate how regulation works when insurance companies optimize their risk management, capital management, and financial management decisions at the same time. A general regulatory requirement could be an exogenous cause of three managerial decisions. This issue will be explored and then findings from that contribute to literature of insurance. We view the regulatory requirement as a latent factor and then investigate how it influences the three managerial decisions. The SEM analysis will be conducted by incorporating the regulatory requirement.

Furthermore, the SEM used here depicts the changing patterns of the management of the insurance industry by introducing regulatory latent variable. Therefore, the SEM is also empirically feasible and practically applicable in the real world.

In summary, this study shows that the effects of regulations on the three major managerial decisions dominate the interactions relationship between the three variables. In addition, as inter-relationship exists among the latent variables, the magnitude of the effects of risk management on financial management and capital management are not necessarily the same as that of the reverse effects from financial management and capital management on risk management.

Table 2 Empirical Results of the Structural Equation Modeling

Panel I Parameter Estimates of First-level Structural Regression

Year	2000			2001			2002		
	Risk Mgmt	Capital Mgmt	Fin Mgmt	Risk Mgmt	Capital Mgmt	Fin Mgmt	Risk Mgmt	Capital Mgmt	Fin Mgmt
Regulation	0.27	0.56	0.83	1.00	1.19	0.95	1.00	1.00	0.98

Panel II Parameter Estimates of Second-level Structural Regression

Year	2000			2001			2002		
	Risk Mgmt	Capital Mgmt	Fin Mgmt	Risk Mgmt	Capital Mgmt	Fin Mgmt	Risk Mgmt	Capital Mgmt	Fin Mgmt
Risk Mgmt	- -	-0.01	0.02	- -	0.00	0.00	- -	0.00	0.00
Capital Mgmt	0.04	- -	0.08	-0.04	- -	-0.04	0.00	- -	0.00
Financial Mgmt	-0.01	-0.1	- -	0.00	0.00	- -	0.00	0.00	- -

Panel III Parameter Estimates of Measurement Equations Regression

Year	2000			2001			2002		
	Risk Mgmt	Capital Mgmt	Fin Mgmt	Risk Mgmt	Capital Mgmt	Fin Mgmt	Risk Mgmt	Capital Mgmt	Fin Mgmt
RePrem	0.50	- -	- -	0.50	- -	- -	0.50	- -	- -
T_Amount	0.83	- -	- -	1.33	- -	- -	0.50	- -	- -
NPW_Gw	- -	16.5	1.00	- -	-0.01	0.53	- -	0.19	0.51
BdPct	- -	-0.58	0.30	- -	0.06	0.08	- -	-0.01	0.00
StkPct	- -	-0.08	0.08	- -	0.00	-0.02	- -	0.00	0.00
MgPct	- -	0.00	0.00	- -	-0.02	0.01	- -	0.01	0.01
RePct	- -	-0.01	0.00	- -	0.01	-0.02	- -	0.00	0.00
(sum of asset risk)		-0.67			0.05			0.00	
Cap_TA	- -	0.56	- -	- -	0.37	- -	- -	0.49	- -
Sup_RBC	- -	-0.01	- -	- -	0.00	- -	- -	0.00	- -
RBC_Reg	- -	2.08	- -	- -	0.09	- -	- -	8.83	- -
LgTail_L	- -	-0.06	- -	- -	-0.01	- -	- -	-0.02	- -
LR_Pro_L	- -	0.00	- -	- -	0.01	- -	- -	-0.01	- -

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AN UPDATE ON DEBIT LIFE INSURANCE IN THE U.S.

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ABSTRACT

Debit life insurance, which includes industrial life, monthly debit ordinary, and monthly debit industrial, is permanent life insurance sold to low and middle-income consumers for burial costs. These insurance products have been in the news for the past few years due to a series of class action suits and state investigations regarding debit insurance, particularly the industrial product. This paper presents the first complete compilation of the lawsuits and state investigations regarding these products. Additionally, the paper provides a history of the debit life insurance industry.

Keywords: debit insurance, industrial insurance, life insurance, underserved populations

I. INTRODUCTION

Debit life insurance products, which include industrial life, monthly debit ordinary, and monthly debit industrial, are forms of permanent life insurance. Debit life insurance historically has been sold to low and moderate/middle-income consumers to cover burial costs. These insurance products have been in the news for the past few years due to a series of class action suits and state investigations regarding debit insurance, particularly the industrial product.

The debit system is primarily associated with industrial life insurance. Several other debit life products evolved from industrial life. These products are less well known, and will be discussed in later sections. Insurance products other than life products marketed through the debit system include health and property and casualty insurance (Alrich & Buckman, 1963).

Although billions of dollars in industrial life insurance coverage are currently in force, little is commonly known about this product. Academic literature has tended to be descriptive rather than quantitative in nature, and few academic studies have been done since the 1960s. Students of insurance typically learn little about the product, as insurance textbooks ether allocate less than one page to industrial insurance (e.g., Vaughan & Vaughan, 2002), or fail to mention it at all (e.g., Beam, Bickelhaupt, Crowe, & Poole, 2002).

Executives in the financial services industry should be aware of debit product related issues so that they can more accurately assess their company's potential risk exposure. This exposure is higher now than prior to the class action suits, which raised the standard of conduct for insurers. Although to date class action settlements have been small relative to company assets, adverse publicity could taint other company products and affect shareholder value. Management should be aware of the character of the insurance products on their books and to determine whether correction action is necessary. Further, managers considering mergers with or acquisition of

other insurance companies should be aware of the debit products and their associated liability exposure.

The purpose of this paper is to describe the current issues related to debit life insurance. This paper presents the first complete compilation of the current lawsuits and state investigations regarding these products. A secondary purpose is to provide a history of the industrial life insurance industry. Prior to this work, a history has not been related since the condensed history related in LaPorte's critique of the industry in 1979.

This paper will begin in Part I by describing the development of industrial life insurance, and characteristics associated with these policies. In Part II, the academic literature is discussed in the context of product features. Court cases and state investigations are discussed in Part III. The paper concludes in Part IV with suggestions for educators, advisors, and financial practitioners working with members of the industrial life insurance target market, and with suggestions for future research.

I. HISTORY AND BACKGROUND

Debit life insurance has been marketed as burial insurance for low- to moderate-income families since the late 1800s. The product has evolved somewhat over the years, but the purpose and target market have remained constant. A recounting of the long history of industrial insurance is helpful for understanding recent lawsuits and investigations related to the product.

The English Roots

Debit insurance products developed in England, where the industrial insurance form was created in the late 1600s. At that time, Friendly Societies and Burial Clubs provided aid to families of deceased workers (Bernstein, 1996). Throughout the 1700s, these Friendly Societies flourished in English communities. The demand for this insurance was driven by the desire to provide a customary burial for the insured rather than a pauper's funeral, which was considered humiliating to the decedent and the family (Marshall & Zubay, 1975).

The funding of the Friendly Society's coverage was unlike that of a traditional insurance product. Each policy owner paid the same premium, regardless of the insured's age or health. Standard actuarial practices such as reserving and underwriting were not observed, even though by 1800, English insurance companies used these methods for their life products (Davis, 1944).

Insurance similar to that of the Friendly Society was introduced in 1848 by the Prudential Assurance Company, Ltd. This insurance was designed using actuarial practices for premium construction and reserving, but the usual extensive medical underwriting was not required. The product was called industrial insurance because it was target marketed to low-income industrial workers. The name industrial life became synonymous with insurance in small amounts for families with limited means ("Industrial Life Insurance", 1905).

The industrial insurer, like the Friendly Society before it, used a debit system for premium payment. With the debit system, also known as home service, a field representative went to the

policy owner's home or workplace to collect weekly premiums and to service the policy (Marshall & Zubay, 1975). Insurers believed that low wage earning policy owners lived paycheck to paycheck, so premium collection should be coordinated with the weekly payday (Davis, 1944).

The Migration to the United States

The industrial insurer, like the Friendly Society before it, used a debit system for premium payment. 2 characteristics in common, the collection system and the small face value. With the debit system, a field representative went to the policy owner's home or workplace to collect weekly premiums and to service the policy (Marshall & Zubay, 1975). Insurers believed that because low wage earning policy owners lived paycheck to paycheck, premium collection should be coordinated with the weekly payday (Davis, 1944).

In the late 1800s, insurers in the United States developed industrial insurance products similar to the British products. In 1875, the Prudential Insurance Company of America issued the first U. S. industrial insurance policy, which provided small amounts of life insurance in exchange for a weekly payment collected by an agent ("Industrial Life Insurance", 1905). A few years later, Metropolitan Life Insurance Company and the John Hancock Mutual Life Insurance Company introduced similar products and for many years, these three companies dominated the American industrial life insurance market.

As with the English products, these American industrial life policies were intended to cover the burial component of the insurance need, and were targeted to low- and moderate-income wage earners. Death benefits were less than $1000 and were based on the premium that the household could afford. Industrial life policies usually included dismemberment benefits, unlike ordinary life insurance policies. Small amounts of cash value built up slowly in the policy, but loans against cash value were not allowed. Unlike ordinary insurance, pricing was based on age last birthday, rather than age nearest birthday (Belth & Leverett, 1965).

Additionally, as with the English products, insurance companies accepted the risk without extensive medical underwriting. Medical underwriting was based on a medical questionnaire and special industrial life mortality tables were used for premium calculation. The industrial life tables reflected higher mortality than standard life mortality tables. Indeed, historically, the death rate experience in industrial workers *did* exceed that reflected in ordinary life mortality tables. Additionally, as will be discussed in the section regarding class action suits, some companies priced their products with a dual set of rate books, one for whites and one with higher premiums for blacks (Harrington & Hauserman, 2000). Simplified issue format after the 1960s

Industrial life insurers were the first to provide coverage on women on a widespread basis. These insurers targeted female homemakers, as well as both single and married working women. Women who purchased debit insurance were usually low and moderate income individuals who worked in blue collar service sectors (Blicksilver, 1975). Women often purchased policies on themselves and every family member, sometimes including minor and adult children and grandchildren (Laporte, 1979). By 1973, although women represented one third of ordinary life purchasers, they owned 44% of industrial life policies (Blicksilver).

The Debit System

Insurers promoted their debit systems as a service to their policy owners. The insurers regarded home service as a help to policy owners who otherwise lacked the discipline to budget for insurance premium payments (Marshall & Zubay, 1975). Additionally the ability to pay premiums in cash was helpful for those without bank accounts (Seaman, 1993).

In the debit system, geographical territories were assigned to debit agents. Each agent was responsible for service to all of the insurer's in-force contracts residing in that territory. The agents were compensated for their home service through service commissions, premium collection commissions, and expense allowances (Marshall & Zubay, 1975).

Development of MDO

In 1926, a variation on industrial life insurance was introduced to appeal to middle-income wage earners. This variation, Monthly Debit Ordinary (MDO), was sold to the downscale market, with face amounts ranging from $1,000 to $15,000 (Seaman, 1993). The average sized MDO policy in 1992 provided approximately $10,823 of death benefit (Seaman). Laporte (1979) reported that, by the late 1970s, MDO sales were growing and had surpassed those of industrial insurance. However, as will be reported in a later section, sales and in force information for MDO is unknown because these data are included with ordinary life data.

MDOs were sold and serviced under the debit system, although the volume and visibility of the product has historically been considerably lower than that of industrial life. Premiums were collected at the policy owner's home or workplace, but on a monthly, rather than weekly, basis (Marshall & Zubay, 1975). The monthly collection synchronized payment with monthly income earned from employment or obtained from government welfare and social security programs (Laporte, 1979).

The MDO products were structured somewhat differently than industrial policies. For example, the cash value in a MDO policy began accruing sooner than the cash value in an industrial policy. Additionally, the insurer may have charged a slightly lower premium than the industrial life insurance plans because the agent did not collect the premium as frequently. Of course expense loading included the extra expense of debit collection. Until the 1950s, MDO insurers used industrial life mortality tables, and after that time, insurers tended to use ordinary life mortality tables.

Product Decline

The amount of industrial life insurance in force in the United States peaked in the middle 1950s (Marshall & Zubay, 1975). Insurance company reports indicate that in the early 1960s, industrial life insurance still occupied an important position in the life insurance market. In 1961, industrial life insurance premiums accounted for 14% of total life insurance premiums paid, while MDO accounted for less than 1% of total life insurance premiums paid (Alrich & Buckman, 1963).

The Civil Rights Act of 1964 legislated changes to the way that industrial life insurers priced their policies. The Act, which banned discrimination because of a person's color, race, national origin, religion, or sex, effectively outlawed the practice of race-based pricing. As a result of the Civil Rights Act, insurers began to eliminate their separate pricing schedules for new policies and to make adjustments to rate-based policies. However, some insurance companies continued to collect in-force race-based policy premiums, which may have been as much as 25 percent more than premiums for white insureds (McKinney, 2001).

Improved general economic conditions contributed to the decline of industrial policies. Wages rose by 42% between 1952 and 1962, compared to a 13% increased cost of living. These economic improvements enabled American workers to purchase higher amounts of insurance coverage than those offered by industrial life policies. In this favorable market, the larger companies began to concentrate more on the sale of larger policies (Alrich & Buckman, 1963).

Responding to the changes due to the Civil Rights Act and the general economic conditions, by the late 1960s, major insurance companies began phasing out the sale of weekly premium industrial policies. These companies included the pioneers of the industry, Prudential, Metropolitan Life, and John Hancock. Other large insurers, also referred to as combination companies because they offered a combination of different lines of business, tended to withdraw from the industrial life industry (Alrich & Buckman, 1963). Although the major insurers phased out active sales of industrial life insurance, smaller companies that specialized in the debit system of marketing continued industrial life sales.

After the 1960s, insurers developed *Monthly Debit Industrial (MDI)*, a variation of Monthly Debit Ordinary, has emerged. Like MDO, MDI premiums were collected monthly, but the premiums for the MDI are higher, due in part to differences in the geographical target markets. The MDIs are targeted to very poor areas, such as housing projects, while MDOs are sold to moderate and middle-income consumers. Around this same time1960s, the debit product began to be referred to as the home service (w1, p4)

Debit Life Insurance Products Today

Today, industrial life insurance is a small component of the life insurance industry, representing .1% of the total life insurance coverage in force, and 6.7% of the total number of life insurance policies in force. In 1998, the last year for which the American Council of Life Insurers (ACLI) reported these data, $17.365 billion in industrial life insurance death benefit was in force, representing 24.065 million policies, with an average death benefit of $721.59. The industrial life insurance industry paid $437 million in death benefit in 1998 (ACLI, 1999).

Industrial life insurance in force is concentrated in a small number of companies. The seven highest volume companies in 1998 accounted for 72% of the in force business, as shown in Table 1. Within the last five years, each of these companies has been associated with a lawsuit or investigation related to the industrial life or debit life insurance business. These suits and investigations will be discussed at length in a later section.

MDO and MDI debit products continue to be offered in the home service arena today, but the annual sales and coverage in force are unknown. Industry reports, such as those from Best's and ACLI, include these products with the ordinary life insurance statistics. Consequently, the numbers cited in the prior paragraphs concerning industrial life insurance constitute only a portion of the debit life insurance in force as of 1998.

II. LITERATURE REVIEW

The academic literature concerning industrial life insurance is sparse, and little has been written since the 1960s. Additionally, the majority of the academic literature is descriptive rather than empirical. The most recent work, Laporte (1979) and Seaman (1993), described issues associated with the industrial life insurance product. Issues that emerged from a review of the extant literature provided the organizing structure for the literature discussion.

Regulation

Insurance in the U.S. has been regulated primarily on the state level since the late 1800s. The McCarran-Ferguson Act of 1945 confirmed the right of the states to regulate insurance, but allowed that the federal government can take over regulation when state regulation is inadequate. As will be seen in the discussion concerning the class-action suits and state investigations, states collaborate in their regulation and enforcement efforts.

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Available on request from either author.

STOCK MARKET PERFORMANCE OF HEALTH CARE INITIAL PUBLIC OFFERINGS

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ABSTRACT

The short- and long-term stock market performance of health care initial public offerings is examined. Annualized excess returns from market are computed from day two for six-months, one-year, two-years, three-years, four-years, and five-years. For six-month returns, the average returns are found to be significant. For the other periods, one-year, two-years, three-years, four-years, and five years, the returns were not significant from zero. However, most of the returns for all of the periods are found to be negative.

KEYWORDS: Initial Public Offerings, Health Care, Stock Market Performance

INTRODUCTION

Initial public offerings (IPO) have attracted a great deal of interest in the marketplace. They have attracted attention due to the tremendous gains associated with certain stocks. In December 1999, shares of VA Linus had a one-day gain of 698 percent when it went public. Another related company, RedHat, went public at $14 and three months later was selling at $300 per share.

Another issue is the long-term performance of these IPO's. Studies have shown that the long-term performance is not encouraging. After approximately a year, the performance of IPO's has not been positive with negative returns.

It would seem that the healthcare industry could possibly be immune from this performance as the healthcare industry is perceived to be a non-cyclical in its performance. In addition, the demographics would suggest that the aging of people would make health care stocks to be immune from the performance of other IPO's. Sales growth in the health care industry is expected to be 15 percent over the next 5 years. Therefore, this study looks at the short- and long-run performance of IPO's in the health care industry.

BACKGROUND

Research on this area has two components. One group of studies looked at the short-run stock performance of IPO's. An average first-day return as measured by the return on the offering price and closing price was 24.19 percent (Ritter and Welch). The overall conclusions of these studies are that IPO's have significant under pricing and that companies are not receiving a significant amount of money.

Long-run stock market performance also has been analyzed extensively. Purnanamdam and Swaminathan (2001) found that IPO's significantly underperformed in the long-run. The study concerned 2000 companies who went public from 1980 through 1997. These stocks significantly underperformed their peers. Ritter had similar results occur in his study.

Loughren and Ritter used a buy and hold approach to IPO's for a three-year period. The time period was from 1970 through 1990. Once again, these stocks significantly underperformed their peers.

METHODOLOGY

Healthcare related companies that sold an IPO from 1998 through 2001 were identified from www.hoovers.com. Eighty-six health care related stocks took part in IPO's during this period.

Annualized returns were computed from the second day of trading. The first day of trading is volatile and other studies omitted the first day from the studies. Returns were computed for 6-months, one-year, two-year, three-year, four year and five years from the second day of trading. Returns for the corresponding S&P 500 index are compared to the returns to observe any variations in these stocks relative to the market. Excess returns are computed for comparison. The period was subdivided into two categories, those that went public before March 2000 and those that went public after March 2000. This coincides with the high-tech bubble that burst in March 2000. Could the period after March 2000 provide long-term abnormal returns? Maybe investors would be more cautious in their approach to IPO's due to previous experiences?

If healthcare IPO does perform like other IPO's, the excess returns should be very high in the short-term (less than one year) and not significant in longer-term (more than one year). This would coincide with the results of previous studies of the IPO markets in general. Will the expected increase in sales cause the IPO market to behave differently for healthcare market?

RESULTS

Six-Month Annualized Returns

For the six-month period, the average excess return was 636.6 percent. This return was found to be statistically significant. However, of the 86 stocks, 52 stocks had negative excess rates of return during the six months after going public. For the period

before March 2000, stocks that went public had a 906 percent excess return. However, it was not found to be significant. For the period after March 2000, stocks that went IPO had a 462 percent excess rate of return and it was found to be significant.

One-Year Annualized Returns

An excess rate or return of 33.6 percent was computed for all healthcare IPO's. However, the results are not significant. Fifty-four stocks had negative excess returns during this period. For the period before March 2000, the annualized return was 37.8 percent. It was not found to be significant. After March 2001, the annualized return was computed to be 30.6 percent and it was not significant.

Two-Year Annualized Returns

When two-year returns are examined, a negative 7.4 percent return was calculated meaning that if you would have purchased the stock on the second day of trading, the stocks underperformed by 7.4 percent. It was not significant. Only twenty-two stocks displayed positive returns. For those stocks going public before March 2000, a 3.3 percent return was found. It was not significant. For the period after March 2000, a negative 14.6 percent return was computed and was significant.

Three-Year Annualized Returns

Three year returns were examined next. A negative 8.6 percent return was observed and it was significant. Thirty-four stocks had positive returns. When the period before March 2000 is observed, a negative 5.3 percent was found and it was not significant. After March 2000, those stocks going public displayed a negative 10.7 percent return. It was found to be significant.

Four-Year Annualized Returns

A negative 7.8 percent return was observed for the four year period. Once again, this negative rate of return was significant. Thirty-two stocks had positive returns. For the period before March 2000, a negative 5.6 per cent return was observed but it was not found to be significant. A negative 9.3 percent return was computed for the period after March 2000. It was not found to be significant.

Five-Year Annualized Returns

Annualized returns for the five year period were a negative 8.3 percent. This result was significant. Only twenty-three stocks had a positive return. A negative 4.2 percent return was observed for the period before March 2000. The results were not significant. When the period after March 2000 was examined, a negative 11 percent return was observed.

TABLE 1
Stock Market Returns of Health Care IPO's
1998 through 2001

PERIOD	OVERALL RETURN	NUMBER OF STOCK WITH NEGATIVE EXCESS RETURNS	PRE-MARCH 2000 EXCESS RETURNS	POST-MARCH 2000 EXCESS RETURNS
SIX-MONTHS	636.6%	52/86	906.0%	462.0%
ONE-YEAR	33.6%	54/86	37.8%	30.6%
TWO-YEARS	-7.4%	64/86	3.3%	14.6%
THREE-YEARS	-8.6%	52/86	-5.3%	-10.7%
FOUR-YEARS	-7.8%	54/86	-5.6%	-9.3%
FIVE-YEARS	-8.3%	53/86	-4.2%	-11.0%

CONCLUSIONS

The results in this study mirrors the results of other studies. There are some very large short-run returns (six-months) above the market. However, the number of negative returns during this period raises issues with following this policy blindly. As with other studies, the long-term return performance of healthcare IPO's was below the market.

One of the more puzzling results was the after March 2000. The long-term performance of the IPO's occurring after March 2000 were significantly negative while those IPO's issued before March 2000 were not significant. The implication was that you would have below market returns by investing long-term in these stocks. In addition, the IPO's after the tech bubble crash had below market returns.

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THE RATE DECISION
ADJUSTABLE VERSUS FIXED RATE MORGAGE

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ABSTRACT

Homebuyers and commercial real estate buyers who borrow funds using mortgages all must face the choice of whether to assume a fixed or an adjustable rate mortgage. Other mortgage forms with alternative characteristics are available, but the deciding question remains the same. Fixed rate mortgages never change over time, but have a high initial rate. Adjustable rate, interest-only or hybrid mortgages begin with lower rates, but they change at fixed intervals over time. This paper shows that with a straight forward forecasting model, the decision is not difficult and relatively risk free. Adjustable mortgages are not always the best choice, especially in a rising interest rate market.

Keywords: Mortgage rates decision; Adjustable mortgage rate; Fixed mortgage rate; Forecasting mortgage rates;

INTRODUCTION

Mortgage borrowers faced with the decision of a fixed or adjustable rate mortgage are often given the rule of thumb that if their horizon period is shorter than five years they should take an adjustable rate mortgage. Lengthy horizon periods necessitate a fixed rate, long term mortgage. The rationale is that adjustable rate mortgages (ARM) are cheaper in the short run, but have the potential for rising in the long run and becoming more costly than a long term mortgage. Therefore borrowers who plan to move or refinance in a relatively short time frame will never face the large rate increases. Some authors have even claimed that all borrowers, regardless of horizons, should choose adjustable rate mortgages because the early expected savings are worth the later risk, see Longhofer (2006).

While horizon periods are one important constraint, they are not the only determining factor of the mortgage decision. Borrowers must estimate the present value of the expected borrowing costs of each type of mortgage and choose the lowest cost. Since ARMs have low early costs, short horizon periods are biased in their favor. However, even with short periods, ARM rates can rise. Rates must be forecast to estimate expected costs, which must then be discounted.

With a fixed rate mortgage, this calculation is straight forward. The interest rate and payment will be set for any period. However, for ARMs, each period may see a higher or lower rate and payment structure. These movements are not random. Indeed, interest rates have risen, fallen and started rising again in cycles over the last two decades. While future turning points may be

difficult to identify, a forecasting model which uses past rates, can soon predict future movements.

This paper will develop a forecasting model for rates and, then, discount several interest rate streams from different horizon periods to the present to determine whether a fixed or adjustable rate mortgage is preferable. The goal is to present a relatively straightforward model that can be used by even unsophisticated borrowers to help them make mortgage choices. We can also see what hypothetical movements cause different choices.

LITERATURE REVIEW

Until 1982, federally insured depository institutions were restricted to offering long term, fixed rate equal payment mortgages to consumers. Adjustable or variable rate mortgages (ARMs) were legalized only when volatile and rising interest rates were driving financial institutions into insolvency. The goal of the new mortgages was originally to protect lenders from interest rate risk in times of rising rates. Since the risk of rising rates is, at least partially, being transferred to borrowers, ARMs have introductory rates and payments which are less than comparable fixed rates at the time of origination.

Despite the fact that rising interest rate scenarios were the driving underlying principle of new mortgage forms, little research has been conducted on the consumer mortgage choice. Instead researchers have concentrated on such topics as the optimal refinancing strategy (Chin and Ling 1989), the determinants of prepayment (Vanderhoff,1996), the probability of a particular mortgage being paid off in any given year (Green and Shovan, 1996), and the role of initial discounts in the pricing of ARMs (Sprecher and Willman, 2000).

Even though ARMs shift interest rate risk to consumers, the adjustable rates can solve one borrower problem if used wisely. Long term fixed rate mortgages exact high rates because future expected inflation is discounted into the current rates. As a result mortgage rates rise before income levels. As a homeowner's income rises, a fixed mortgage payment becomes a smaller percentage of gross income for the homebuyer. This phenomenon is referred to as the Tilt Problem (Alm, 1984). Buyers able to get into the real estate game have no problem. However, those that do not have a high enough income to cover the payments on a fixed rate mortgage either do not buy or buy a less expensive house with a smaller mortgage. They have a tilt problem because the falling payment to income ratio prevents them from buying a house at high interest rates. Since ARMs are short term not long, there is no upfront tilt problem. Rates rise over time as, presumably incomes do.

In recent years, ARMs have increasingly been used by consumers to qualify for large loans rather than to take advantage of interest rate trends. Lenders refer to ARMs and interest-only loans as 'affordability' products in the current era of relatively high home prices. In a rational, albeit uncertain, world, consumers would take out ARMs when rates were high and likely to fall. For the last few years, interest rates have been very low and, therefore, not likely to fall further. The threat of rising rates has been discussed in the popular press repeatedly. In addition, while short term rates have been rising, long term rates have not. Nevertheless, in 2005, 26 percent of all home loans were interest –only and 15 percent were ARMs Some geographic areas with high

cost housing had even higher rates of non-fixed mortgages. Clearly these borrowers are looking for a way to solve the Tilt problem.

FORECASTING MODEL

Forecasting interest rates correctly, especially for long periods of time, is difficult if not impossible because the determinants of interest rates lie with monetary authorities, currency exchanges, the demand for funds and other monetary variables. However, short term forecasting of a few years is simpler. Borrowers need a relatively simple forecast model based on recent rate changes.

In this study, we use a Time-Series Model. Time-series models are particularly useful when little is known about the underlying process one is trying to forecast. The limited structure in time-series models, however, makes them reliable only in the short run.
This type of model ignores the causes of interest rate changes and assumes future rates are dependent only on past rates. In other words, we examine the past behavior of the time series in order to infer future behavior. To model the fixed and adjustable mortgage interest rate time series, we first visually examined the graph of the series over the past three years to construct an easy to use, easy to implement model that provides a "good forecast" method. The Time-Series Model method used to produce a forecast may involve the use of a simple deterministic model such as a linear extrapolation or the use of a complex stochastic model for adaptive forecasting. To make this model easy to implement, we used the former.

Each method of time series analysis involves a different degree of model complexity and presumes a different level of comprehension about the underlying trend of the time series. The trends in the smoothed both series using the usual moving average Method indicate evolving changes in the series level to be highly nonlinear.

In order to capture the trend, one may use the Moving-Average with Trend (MAT) of order n, where n is a positive odd integer number. We applied the MAT method to both time series with optimal parameter n = 3. The MAT method uses an adaptive linearization of the trend by means of incorporating the local slopes of both the original and the smoothed time series. For technical details see Arsham (2006b).

The actual data for interest rates from 2003 through 2005 obtained form The Federal Finance Housing Board Web site database. The data is based on loans used to purchase single-family non-farm homes. Only conventional non FHA or VA insured mortgages are used. This study used effective rates, which include amortized initial charges, rather than contract rates. We have considered the effective rates series which include amortized initial charges; and the rates that would have been forecast using the MAT model; finally, the error terms in the forecast. The expected error should be close to 0.

ADJUSTABLE VS FIXED RATES 2003-2005

A mortgage borrower might ask of what use such graph would have been to him if he had needed funds over this period of time. To make the ARM vs. Fixed Rate decision, the borrower must consider the present value of the savings from the lower arm rate versus the present value of the excess cost if the ARM rate rises above the fixed rate. Thus, the decision is not just about future costs, but when they occur and the appropriate discount rate to use in calculating the present value.

If a borrower chooses a fixed rate, he knows the future cost. However, if he chooses the ARM, the savings are uncertain after the initial period. Thus, he must forecast the future.
Reviewing the period 2003-2006 shows that fixed rates were relatively stable. In January of 2003, the fixed rate was 6.11 percent. By January, 2006, it was only 6.46 percent. In the same period, the ARM rate was more volatile, but had risen from 5.26 percent to 6.01.

Considering the adjustable rates over the three year period and the set rate that a fixed rate loan would have cost in January, 2003, a borrower who had taken out a fixed rate loan in 2003 would have received a rate of 6.11%. Adjustable rates did not rise above 6.11 for 3.5 years. Thus for 39 months, the borrower would have saved money by taking out an adjustable mortgage. However, a borrower in January 2004 would not save as much. By January, 2004, the fixed mortgage rate had fallen slightly to 5.95 percent. The adjustable rate was 4.98 percent. The adjustable rate remained below the fixed rate for only23 months or 2 years. The present value of these savings would depend on the size of the loan and the discount rate. It would also depend on the refinance costs, if the borrower decided to move to a fixed rate at the time of crossover. In the current cases, since fixed rates remained at or about the same level, a borrower could switch into a fixed rate that would be approximately the same as the one originally available. An alternative strategy would be to remain with the AR and hope that rates would fall back below long term rates. However, given our forecast below, such a strategy, at this point, would be very risky.

Increasingly the time period in which savings would occur is shorter, and, by January, 2006, the borrower would save for only four months.

FORECAST

The prior section showed a review of the actual rates from January 2003 to May, 2006. In this time period, adjustable rate mortgages rose. The margin between fixed rate and adjustable rate narrowed and finally became negative. A borrower in 2006 could have saved for a few months but no longer. The margin was very small and the savings would not have been substantial.

The question at this point is the future, past that of the actual data. Using the MAT model described in Section III, the ARM rate and the fixed rate are forecasted for the next three months. The fixed rate in May, 2006 was 6.73. The adjustable rate in that month was 6.46 percent. The ARM rate is forecast to rise above 6.73 in three months. Using this simple forecasting model, a borrower could easily realize that any immediate savings from the ARM would be short lived. The present value would be very small indeed.

CONCLUSIONS

Actual adjustable and fixed rates for the first forecasted period were 6.52 and 6.79 respectively. Therefore, the absolute relative errors percentage, Arsham (2006)[b] are:

$100|6.52 - 6.56| / 6.52 = 0.61\%$, and $100| 6.79 - 6.80| / 6.79 = 0.15.\%$,

respectively, both small enough to conclude the forecasting method used is "good" for short-terms. Any attempt to forecast long –term, runs the danger of occurrence of turning points which are not an easy task to forecast.

Our short term forecasting model would allow borrowers to predict the direction of interest rates over several months. The amount of savings in that period would determine whether the choice of a fixed or adjustable term mortgage should be made.

Notice: *The original data, the forecast tables, and a collection of graphs for this paper are available upon request from the first author.*

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"TAYLOR RULE SHOCKS AND SECTOR OUTPUT"

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ABSTRACT

This paper compares the effect on sector output and real GDP of shocks to Taylor rule generated values of the Federal Funds rate (FFR) with shocks to the actual FFR in a vector autoregression (VAR) model.

INTRODUCTION

From May 2004 until July of 2006 the Fed raised the Federal Funds rate (FFR) incrementally and steadily from a historic low (by recent standards) of one percent to five and one-quarter percent. These increases have raised questions about their likely impact on sector spending and real GDP. One way to get an early idea of what the impact is likely to be is illustrated in this paper. Using data from an earlier period, it employs Taylor rule estimates of the FFR in a vector autoregression (VAR) model to estimate these impacts. The results are compared to estimates that use the actual FFR over the same period. The method of comparison is a pairwise view of the sector and real GDP impulse response functions.

ESTIMATION

Figure 1 shows the correlation of Taylor rule estimates of the FFR with actual FFR values. The equation for constructing this rule is as follows:

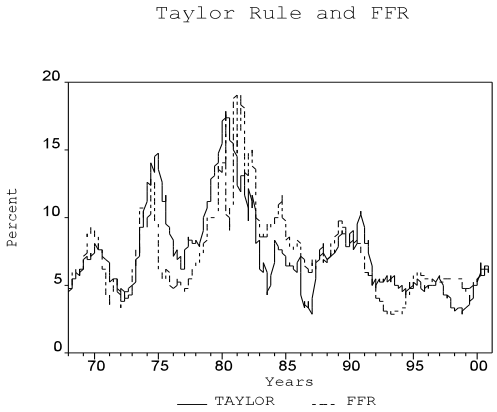
FFR = 1 + 1.5(% inflation rate) + 0.5(% output gap). (1)

It assumes a target inflation rate and an equilibrium FFR of two percent. Although Taylor's original equation was based on a smaller sample period, when it is extrapolated backward and forward to include the sample period of this paper, it has a 0.7 correlation with the actual FFR series. As a prelude to estimating both sets of VARs, Granger causality tests were run on the Taylor rule FFR estimates and the actual FFR. The null hypotheses tested were that FFR did not Granger cause sector spending/real GDP. The results are shown in Table 1 and 2.

Based on Augumented Dickey-Fuller/Phillips-Peron unit root tests, the FFR was only marginally stationary. It is convenient to assume that it is nonstationary, since the sector spending variables and real GDP exhibit a strong upward trend and are also nonstationary. Econometric theory suggests that this allows for the possibility that cointegration may exist between the FFR and the spending/GDP variables. Thus, the assumption behind each estimated

VAR in this section is that each sector spending variable, as well as real GDP, is cointegrated with the FFR, and contains a trend and an error correction term. Moreover, each VAR was estimated with 18 or more lags, to be consistent with the lag length of the FFR and real durable goods unemployment rate. See [12, pp.183}. The result is that all of the impulse response function graphs have "V" or "U" shapes to them. It turns out that the impulse response function (IRF) graphs of the Taylor rule estimated FFR match up quite nicely with the IRF graphs of the actual FFR.

Figure 1



correlation = 0.7

Table 1

Granger Causality Tests for Real GDP/Sector Spending
and the FFR 1968:01-2002:12

Sector	Lags	F-Stat	Prob
Real Durables	3	2.50	0.084
Real Nondurables	3	5.50	0.0046
Real Services	3	6.80	0.0012
Residential Structures	3	14.80	6.5E-07
Nonresidential Structures	3	0.83	0.44
Business Equip & Software	3	2.95	0.0533
Change in Inventories	3	6.05	0.0026
Real GDP	3	13.39	2.7E-08

Table 2

Granger Causality Tests for Real GDP/Sector Spending
and Taylor Rule Generated FFR Values 1968:01-2002:12

Sector	Lags	F-Stat	Prob
Real Durables	2	4.52	0.004
Real Nondurables	3	6.53	0.00026
Real Services	3	8.38	2.1E-05
Residential Structures	3	12.4	9.4E-08
Nonresidential Structures	3	6.7	0.0002
Business Equip & Software	3	6.43	0.0003
Change in Inventories	3	4.8	0.0027
Real GDP	3	12.9	5.0E-08

Figure 2
Sector/Real GDP Impulse Responses to Taylor Rule Shocks

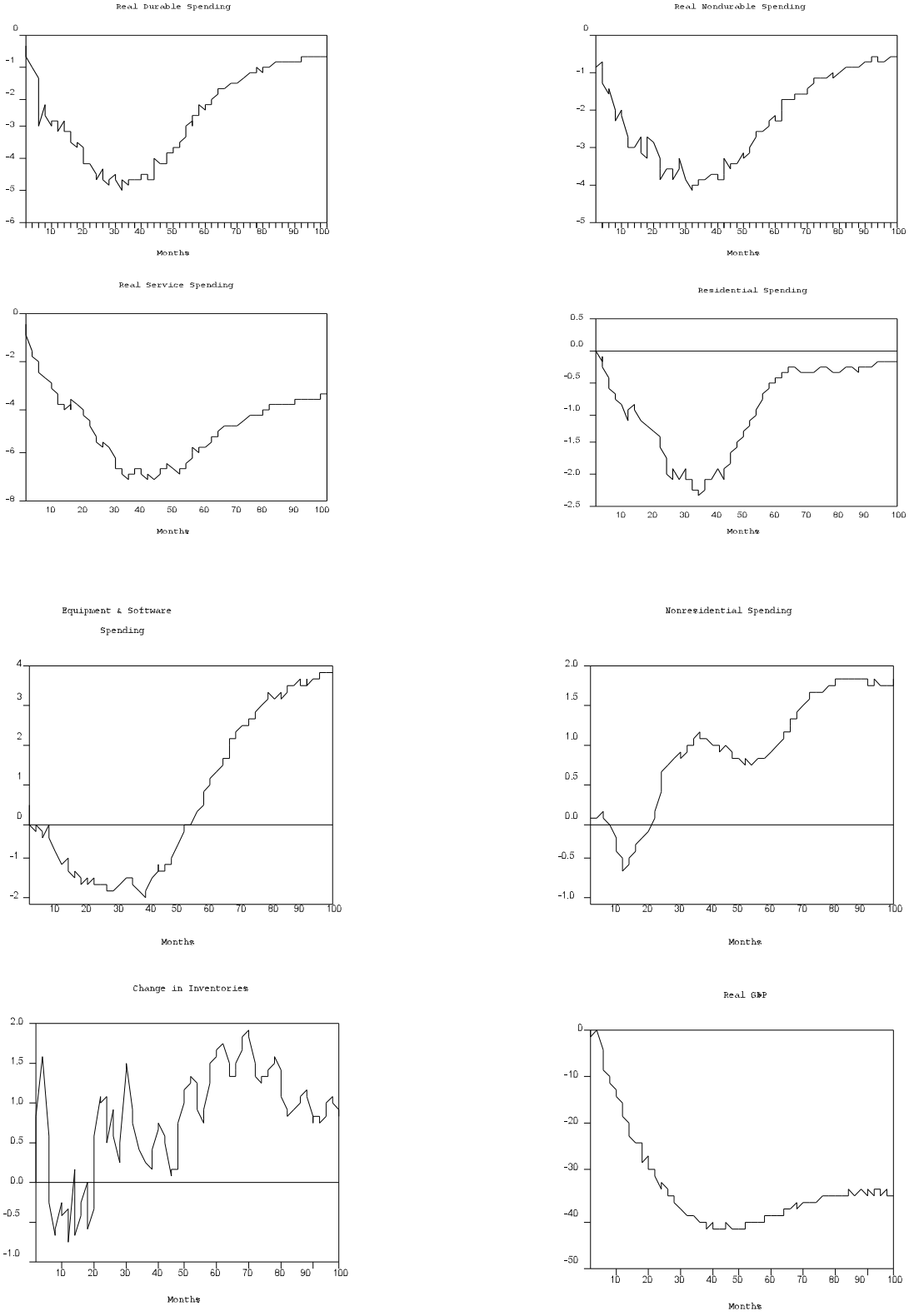
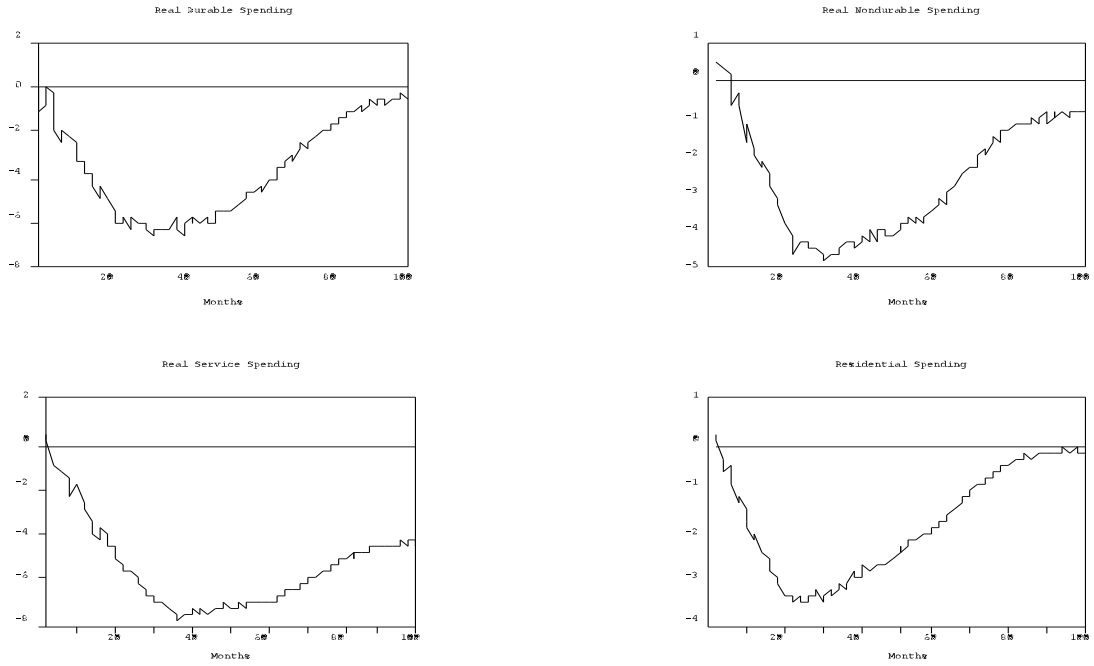
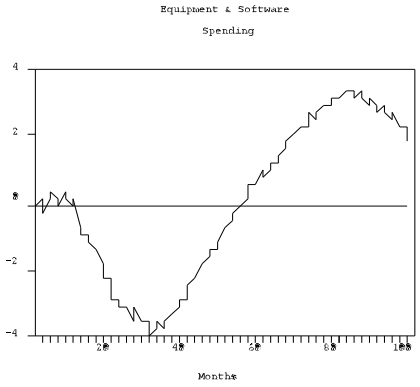
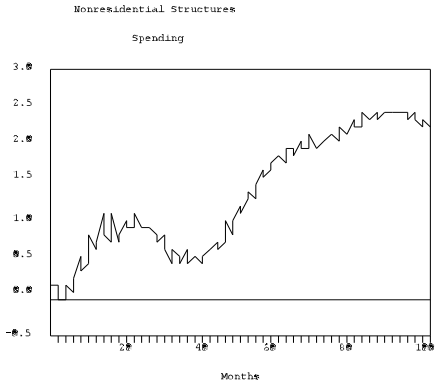


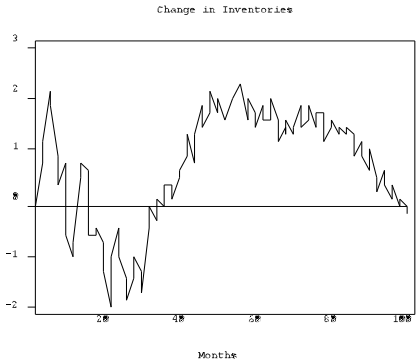
Figure 3

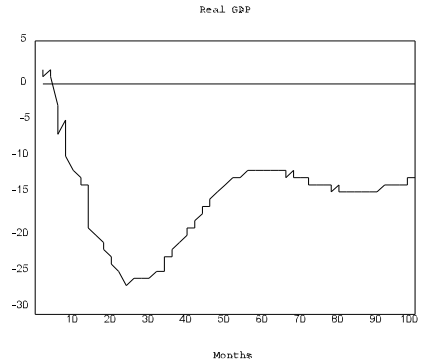
Sector/Real GDP Impulse Responses to FFR Innovation




Equipment & Software
Spending
Months


Nonresidential Structures
Spending
Months


Change in Inventories
Months


Real GDP
Months

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FUNERAL HOMES: PREPAYMENTS AND REGULATIONS

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ABSTRACT

Prepaying for funeral services is increasingly popular, especially for individuals repositioning assets to qualify for Medicaid. With funeral prepayment, individuals pay now in exchange for the funeral home's promise to provide services later. This arrangement is similar to those of other institutions whose promises the public relies on, such as banks and insurance companies. In this paper, we provide an exploratory review of the prepaid funeral industry and its regulation to compare the funeral industry to others that provide promises to the public. As a result of this research, households and their advisors will be more knowledgeable about prepaid funerals and the inherent trust implied in the funeral home's promise to provide posthumous service.

Keywords: funeral homes, Medicaid spend-down, pre-need contracts

I. INTRODUCTION

Although there are many things in life one can avoid, dying is not one of them. Eventually, we will all pass away and be in need of some type of posthumous services or memorial. In anticipation of this need, more and more Americans are arranging for and purchasing their own funeral and burial goods and services on a pre-need basis. Generally, these agreements are between the individual and the funeral director, and are funded through a funeral trust, annuity, or insurance policy (Hermanson, 1999).

Some people prepay for their funeral services to avoid leaving the burden to their loved ones while they are already dealing with their grief. Others do it to personally finance their funeral and to receive the proper type of funeral service they desire. Another incentive is to "spend down" assets for Medicaid, as prepayment of a funeral or cremation is a legal shelter of funds (US Dept of Health & Human Services, 2006).

A complication involving pre-need agreements is the length of time between the signing of the agreement and the need for the goods and services described in the agreement. When you prepay for a funeral service how do you know that the funeral home will still be in business when you die? Where is the payment held so that it will be available when the funeral home incurs the expenses? How can you be sure the funeral home manages the money properly so that it can provide the services in the future, and that the amount paid will be sufficient even with price increases?

When banks make promises to repay their depositors, the Federal Deposit Insurance Corporation backs the bank's promise for up to $100,000. When insurance companies make promises to their policy owners, a state insurance fund backs the promise to pay contractual claims. Who backs the funeral home's promise to provide the goods and services necessary for a decedent who has

purchased a pre-arranged service? What regulations protect consumers from unscrupulous sellers of pre-need funeral goods and services?

The purpose of this exploratory research is to address the consumer protection laws and industry practices that ensure that a pre-need arrangement will actually be carried out at the death of the consumer. Regulations that apply to prepayments for funerals and the security of those prepayments are reviewed and summarized.

II. BACKGROUND

The American Funeral Industry emerged following the Civil War. A major turning point in the awareness of embalming was the cross country journey of Abraham Lincoln's body after the war. The importance of preserving the body of such a beloved public figure provided great public awareness of embalming technology and increased the acceptance of this practice.

The practice of embalming grew for a variety of other reasons, nurtured by the marketing practices of the industry. Funeral Instructors for embalming chemical companies would travel around offering courses in the trade and providing diplomas signifying professional status. The newer techniques were also considered a healthier process than prior practices. Lastly, it became more socially important to provide mourners with a pleasing, well-preserved, and viewable corpse.

The industry developed further with the growth of casket manufacturers, florists, cosmetic corporations, automobile companies, cemetery associations, and other related businesses that support the funeral industry. Together, they built a financially successful industry, which was generating billions of dollars by the end of the 20th century.

The public image of Funeral Directors has been stained by bad press, ugly controversies, and ghoulish stereotypes. Undertakers, Morticians, or Funeral Directors have a tough time convincing people of what they consider to be their professional status. The funeral industry is also attacked for economic reasons, as its high costs and large mark-ups may seem unfair to vulnerable families who are under much stress at the time of purchase and who may not comprehend the financial consequences of their decisions.

This research focuses on one aspect of the modern funeral industry, the prepaid funeral contract. This contract is a legal agreement which says the consumer will pay now for funeral services that will be required in the future. This may include the funeral, burial, or cremation service as well as funeral merchandise such as the casket.

Academic literature on the funeral industry has been developed by a variety of disciplines. The topic has been addressed in journals of public and occupational health, psychology, and culture. Researchers in social, psychological, and religious work have also addressed the topic of funeral homes. However, no recent literature in this area has been published in the areas of finance or financial planning, and in particular there is no literature that addresses the public trust that funeral homes enjoy.

III. DATA AND METHODOLOGY

At first, the majority of data came from funeral home websites and literature on the funeral industry. From this original search came many questions and concerns about prepaid arrangements. These questions formed the basis for an interview with a Funeral Director. In addition, a visit to a funeral home was conducted and documents provided to consumers by the home were critically reviewed.

The majority of the questions for the Funeral Director were answered by the pre-need agreement and pamphlets that the Funeral Home actively uses. The Funeral Director that I interviewed is an experienced director who owns his own home in New York State ("Subject Funeral Home"). He described to me the entire process of the prepaid agreement and the New York State guidelines which he had to follow.

IV. FINDINGS

Prior to conducting this research, there were several unanswered questions regarding the financial arrangements for funding prepaid services. All pre-need funds paid to a funeral firm must be held in trust for such person by the funeral firm. This money is deposited into an interest bearing account in a depository institution. Originally, this research questioned the backing provided to consumers who have purchased a pre-need arrangement. Because the law requires the funeral home to set up a commercial bank or thrift deposit account, the Federal Deposit Insurance Corporation provides security on the account.

Funeral home regulation is on the state level, so details vary across states. The Pre-Need Funeral Consumer Protection Act in New York addresses monetary issues with the depository institution and the funeral home. To provide financial protection to prepaid consumers in New York, funeral homes must annually provide the person who made such a payment with a statement identifying the location and annual interest earned by the account. Thus all prepaid customers must be kept informed of the financial status of their account. Another consumer protection is the prohibition of the transfer of moneys to the funeral home prior to the death of the consumer. As a result, these funds are not in actuality available to the funeral home until the consumer's death.

The industry is also subject to some self-regulation. A trade organization, the National Funeral Directors Association, sponsors the Certified Preplanning Consultant (CPC) professional designation. This designation requires designees to pass a written examination, meet experience and/or licensing requirements, and conform to a professional Code of Ethics. This Code of Ethics outlines the CPC's obligations to the family, public, and government (available at http://www.nfda.org/page.php?pID=563).

There are two categories of funeral contracts relative to future price increases. In the case of a "guaranteed" funeral, the contracted future services are not affected by subsequent price increases. For this contract, the funeral home has accepted the principal and interest for the contracted services as payment-in-full.

The second category of contracts is "non-guaranteed". This contract charges the current price for funeral items and services selected at the time of the contract. At the time of death, the principal and interest in the account will be applied to the funeral home's total charges. If this amount does not cover the expenses, the decedent's estate will be charged the difference. If the amount in the pre-need account is greater than the funeral costs, the excess money will be refunded to the decedent's estate.

Another question regarding the contract related to its revocability and portability. In New York, the consumer can withdraw funds or change funeral homes at any time. According to the Pre-Need Agreement for Subject Funeral Home, the purchaser may cancel the Agreement at any time in writing before the Funeral Director furnishes the funeral services, and shall receive a full refund of monies contained in the pre-need account, including interest. This revocability is not consistent across states, as some states allow irrevocable contracts.

The exception to this revocability in New York applies to Medicaid applicants or recipients. The law requires this agreement to be irrevocable for applicants for receipt of supplemental security benefits under section 209 of the social services law, or of medical assistance under section 366 of the social services law. Leftover money in this situation will go to the county in which the consumer resides.

In New York, the consumer can change funeral homes at any time. The Customer/Director/Bank Agreement for Subject Funeral Home states that the purchaser may change selection of Funeral Director at any time to any other funeral director either within the State of New York or any other state. This law provides consumer protection in two separate areas. First, it allows prepaid consumers to move away from their home after making prepaid arrangements with a funeral home without suffering a financial loss. If a person moves, they can easily regain access to their money or simply change funeral homes. Secondly, prepaid consumers are protected in the case that the funeral home goes out of business or becomes less desirable as a service provider.

The delivery of services by the funeral home is regulated by the same consumer protection laws that cover purchases of other goods. The quality of service issue is a concern due to the uniqueness of the pre-need product. Services will not be provided until after the consumer's death, when that person is unable to assess the quality of service or its consistence with the contract. For example, the funeral home could simply use a cheaper casket than the one contracted for, and the decedent consumer would not be aware of it. Further, consumers are often elderly and may be in poor mental and physical health when they execute the contract. They may be vulnerable to being taken advantage of, and may more concerned with spending down their assets for Medicaid than assessing what their dollars will buy.

Spending down for Medicaid qualification provides a significant market for the pre-need contract. In the visit to the funeral home, literature regarding Medicaid was prominently displayed. For example, one of the pamphlets on display was titled, "Exempt Resources for Medicaid".

Because the funeral home will benefit at the death of one of their prepaid customers, it can be argued that moral hazard arises due to the desire of funeral homes for their consumers to die sooner rather than later. This moral hazard is mediated somewhat by the ability to revoke

(except for Medicaid beneficiaries) or transfer the contract. However, as corporations diversify their holdings, it would be possible for a corporation to own companies that provide medical services or insurance as well as funeral homes. Clearly, if acting in concert, actions of the prior companies providing poor medical care or withholding funding for care, could benefit the latter companies by accelerating their revenue.

V. CONCLUSION

There is very little federal regulation concerning the funeral industry and state regulation varies across the country. The results from this study are based on consumer protections according to New York State Law and the state's Pre-Need Funeral Consumer Protection Act. Compared to other states, New York contains more strict laws concerning the funeral industry and prepaid plans, but fails to provide absolute protection.

The funeral industry in general, and the pre-need contract in particular, inherently provides services to vulnerable populations. The funeral industry has unique opportunities to take advantage of the decedent status of their consumers. Service and merchandise may be delivered inconsistent with the contract without the knowledge of the consumer or the survivors. For example, some elderly consumers may have outlived their families, or surviving family members may have re-located or lost touch.

While it is clearly both unethical and illegal to under-serve a pre-need customer, there is little standardized regulation or oversight of the delivery of these services. Planning for a third party probable survivor to oversee or monitor the prepaid funeral contract administration can help ensure that the contracted services and products are actually provided. However, there are certain instances where the inclusion of a third party is not possible.

Even if surviving family members are involved, the prepaid customer may have failed to inform them that he or she has already made funeral arrangements. It is possible that their relatives will select a different funeral home and pay again. The original funeral home needs only to present a certificate of death to the bank to receive the prepaid account of the decedent consumer even though the service has been handled elsewhere at the family's expense.

Despite the inability for the consumer to enforce all aspects of the contract, some safeguards are in place. These include state laws regarding the financial contracts, and the usual consumer protection laws for goods and services. Additionally, an industry professional designation requires that designees adhere to a Code of Ethics (although the extent of enforcement is not known).

Consumers considering prepaid agreements should assess the advantages as well as the risks discussed in this research. The benefits for the prepaid customer include relieving the survivors of the burden of both financing and organizing the funeral during a time of a great deal of stress. Another benefit is that consumers can set in place the mechanism for fulfilling their wishes at death. Finally, prepaid arrangements are beneficial to Medicaid applicants who are looking to spend down on assets.

Potential prepaid customers should choose the funeral home carefully. Ideally, choosing a funeral home that has previously served the family or friends, or has been recommended by a personal contact would be good options. If neither of these possibilities exists, consumers should check with Better Business Bureau for complaints and should learn about the funeral home's reputation and history. There are several websites available that advise regarding the selection of funeral homes, for example the American Association of Retired Persons website (http://www.aarp.org/money/wise_consumer/smartshopping/funerals.html).

In summary, pre-need consumers should take steps to ensure that the contract is appropriately administered. This paper suggests dealing with a trustworthy funeral home, informing a probable third party survivor of the contract's existence, and arranging for a probable survivor to verify that the services provided are consistent with the contract. As a result of this study, individuals and their advisors will be more informed about prepaid funerals and consumers' rights.

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Available on request from the author or faculty advisor.

A SOLDIER'S FORTUNE: FINANCIAL FACTORS IN THIS CAREER CHOICE

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ABSTRACT

The decision to enlist in the U. S. military on active duty is one that requires much thought and consideration. Soldiers receive personal and financial benefits while facing significant risks during their time on active duty. The purpose of this paper is to identify the financial benefits of a college graduate becoming an active duty U.S. soldier in today's Army. Further, the study will review the financial impact of this post-graduation enlistment on those actively serving today. The results of this study can be helpful for college students considering military enlistment at graduation.

Keywords: career planning, job seeking, military service

I. INTRODUCTION

As the global war on terror continues and the security of the American citizens remains in jeopardy, the United States Military is of great importance to our country. The service of these brave men and women is often associated with intangible qualities such as humility, honor, and integrity for performing tasks that the average person would avoid. Unfortunately, with unforgiving economic realities, these qualities do not pay the bills at the end of every month. Financial hardships associated with military service can diminish the merit or value of service in the eyes of citizen applicants considering enlistment in active duty.

Financial hardships contribute to what some believe to be a problem in accelerating declines in the rate of active duty enlistment relative to the needs driven by America's growing global military presence. For example, the *Washington Post* reported "The Army announced that it missed its recruiting goal for the fourth consecutive month, a deepening manpower crisis that officials said would require a dramatic summer push for recruits" (Tyson, 2006). It is fairly easy to envision that while those officers in infantry units combat the insurgency in Iraq, those involved with making recruiting quotas combat this reduction of enlistment.

Recruiting and incentives for enlistment play an extremely vital role in maintaining adequate military troop levels to supply worldwide demand of combat deployments. Recruiters provide candidates with applicable information that pertain to their interests and qualifications. Factors such as "the Army putting more recruiters in the field and increased bonuses for signing up" (Robertson County Times, 2006) can fuel increased enrollment.

People join the military for many reasons, usually every soldier has his or her own story. Often it is a call to patriotism, sometimes a feeling of honor and bravery to serve one's own country (Mott & Poole, 2005). For those who have not experienced much success or expressed much

motivation in starting a career, the military may be attractive for its imposition of discipline and order in one's life. Deterrents to enlistment include occupational hazards associated with military service, especially in a time of war. Separation from one's friends and family can often serve as a deterrent for someone contemplating military service as well. With all these factors considered, financial benefits are more easily measured to justify a decision to become an active U.S. soldier.

For various financial reasons such as full time salary and full medical benefits, the Army is much like working an ordinary job. In military service there are opportunities for advancement as well as prospects for earning lucrative occupational bonuses. With these bonuses come training and job experience that will often benefit a soldier. All military personnel are invited to use their time in the military to experience educational benefits such as the G.I. Bill, which provides up to 36 months of education benefits for college, business, technical, correspondence, or vocational courses, apprenticeship or job training, or flight school. Participants can receive over $36,000 in tuition (GIBill.com). If citizens have outstanding educational loans, they may elect to take part in the Army's Loan Repayment Program, which helps those who have already attended college to pay off their existing educational debt. Provided soldiers do not violate Codes of Military Justice, the Army will provide a sense of job security for the entirety of one's enlistment contract. This job security comes with the benefits of full medical, dental, and eye insurance, discounted continuing education, allowances for food and housing, and a full time salary.

Recruiters must be able to attract college graduates by offering benefits competitive with the private sector. For college graduates who score well on the military entrance exam, and perform well in physical training, the opportunity to attend Officer Candidate School and become a commissioned officer of the United States Army may very well be their career path. Being an officer is much like being a manager in a corporate setting, and offers this type of experience for the soldier. For those who don't have this path to leadership, traditional job training can be provided to those who choose a field different than what they studied in college, and thus is an opportunity to get a fresh start.

The purpose of this paper is to identify the financial benefits of becoming an active duty U.S. Soldier in today's Army for a college graduate. Further, the study will review the financial impact of this post-graduation enlistment on those actively serving today.

The results of this study can be used by the various different entities depending on the perspective taken. It can be used by the Army Recruiters to try and revise their current marketing strategy on college graduates by taking into account the financial responsibilities of these students when they get out of school and how the Army can help them succeed in managing these responsibilities. The results of this study can also be used by college students and college graduates in helping them consider military service when they have finished school, and also help them finish school if their current financial situation does not allow them to.

II. BACKGROUND

The United States Army was created in 1775, at the commencement of the Revolutionary War to

meet the military demands of the conflict and protect those whose lives and liberty was at stake. The United States Army is the country's oldest and largest military branch with primary operations being land based. The Army has changed significantly over the past two centuries to adapt to the adversarial opponents of the United States. According to the U.S. Army's fiscal year report of 2004, there are currently at a total strength of 1,041,340 soldiers, of which approximately 494,291 are active duty. The active-duty servicemen and women represent nearly half of the total U.S. Army military strength. Of this number of Active-Duty soldiers, approximately 68,634 of these soldiers are commissioned officers. According to multiple reports, most of the commissioned officers in the Army have a minimum educational level of a college degree. In contrast, the majority of enlisted personnel have a minimum educational level of a high school diploma.

Commissioned officers represent nearly 13.9% of the total active duty military strength. These commissioned officers of the U.S. army serve managerial roles in support of enlisted personnel. Although their job duties can be equally traumatic and physically demanding, officers are characterized by a higher level of responsibility and the license to use authority to complete objectives. With this greater responsibility, as with any job in the private sector, comes greater reward and compensation. Although all college graduates who enter the military do not necessarily serve as officers due to a variety of factors, including a lower aptitude for leadership, a college degree greatly enhances the possibility of an active-duty soldier becoming a commissioned officer.

"Regardless of commissioning method, a college education is considered to be a prerequisite for many officers today. Roughly 98% of all officers in the military had at least a 4 year college degree in 1996. During the history of the U.S. military, the distinction between regular and reserve commissions has been important. Prior to the drawdowns of the armed forces in the 1990s, regular officers had substantially more protection against reductions in force, a much greater likelihood of being allowed to continue on active duty past their initial period of obligated service, and varying types of preferential treatment relative to officers with reserve commissions. An example of the type of job security provided by the regular commission during the drawdown was observed by the fact that officers with reserve commissions were asked to leave the military before peers who had regular commissions"(Thirtle, 2005)

"College graduates who enter the military are eligible to enroll in the U.S. Army's student loan repayment program. Individuals enrolled in this program earn 33 1/3 percent or $1,500, whichever is greater, toward the remaining original unpaid principal on all qualifying loans for each successfully completed year of enlisted active duty. (Note: Until April of 2006 Officers and enlisted members becoming officers prior to completing initial enlistment were not eligible for LRP.) This creates an enormous benefit for college students looking to join the active-duty military."

"According to a report by USA Today, the average college educated individual graduates and assumes over $19,000 of personal student loan debt. After years of rising college costs and shrinking financial aid, it's come to this: Some graduates are now leaving college with student-loan debt in the six figures. In 2004, nearly 8% of graduating seniors carried student loans of $40,000 or more, according to the Project on Student Debt, a non-profit advocacy group. In

1993, even adjusted for inflation, only 1.3% of college seniors had debt that large, says Robert Shireman, director of the project. The rise in unmanageable debt has raised concerns that many graduates won't be able to pursue careers in fields that have traditionally paid modest salaries. Nearly a quarter of four-year public-school graduates and 38% of private-school graduates who become teachers can't afford to repay their debts on a starting teacher's salary, a recent report by the Public Interest Research Group's Higher Education Project found."

"Depending on the loan amount, the term of the loan can be extended from 12 to 30 years. The reduced monthly payment may make the loan easier to repay for some borrowers. However, by extending the term of a loan the total amount of interest paid over the lifetime of the loan is increased."(www.finaid.org/loans/consolidation/.html)

"With a low end average around twenty thousand dollars, which does not accurately represent the average obligation of those who attend more expensive private universities nor does it calculate the average borrowed by parents or guardians, still represents approximately a two hundred and fifty dollar obligation monthly to pay off the loan over a ten year period."

III. DATA AND METHODOLOGY

To determine the financial impact the U.S. Army has had on Active Duty Soldiers, interviews were conducted with members of the Army's 3rd Infantry Division, a mechanized infantry unit that has endured multiple deployments to Iraq and Afghanistan. They have played a significant role in battling the insurgency and protecting America's soil, sacrificing even the lives of their men to protect the freedom and way of life we are enjoying today. The interviews were conducted through the months of October and November 2006. A list of interview questions is available from the author or faculty advisor.

A list of financial benefits of serving in the Active Duty military service as a college graduate was created from an analysis of readily available information regarding programs and policies of the military and their impact on the financial situations of active-duty servicemen and servicewomen. Then a private sector job market scenario was created with the use of average entry-level job market characteristics to be used in comparison with the military job sector. Using this data, a survey was created to establish the current financial situations of a select number of soldiers and how the U.S. Army, good or bad, made an impact on their educational costs.

The propensity to advance in a soldier's career was also averaged between the participants to calculate and compare with career development of the private sector. To compute career advancement, information regarding their starting pay-rank and current pay-rank was analyzed to determine the average length of time it took to be promoted. This information was then corroborated with information from the Bureau of Labor Statistics. To establish a comparison of the level of job security, information gathered on the level of worker displacement over the last few years was contrasted with information garnered by the soldiers on their feeling of their own job security. Using these variables, a judgment on the career development in the U.S. Military, particularly the Active Duty Army, and how it measured up to that of the private sector.

Educational assistance is a very large component of the Army's marketing campaign towards young men and women. The seemingly alluring notion of a free education after or before the fact is certainly a tempting benefit to a soldier (Mott & Poole, 2005). In general, information gathered from surveys, labor statistics, and Army policies were collectively analyzed to determine the overall impact that military service has on college graduates with relation to finances.

IV. FINDINGS AND CONCLUSION

The data suggested that participants considered the educational assistance provided by the U.S. Army as overall effective. Job security seems to be higher in the military than the private sector. Since all those who interviewed were officers, each had incurred educational expenses along the way, not including the West Point graduate who had a military obligation rather than monetary commitment.

Although private sector employment offered a more lucrative base salary, when educational cost repayment is factored in, the playing field is effectively leveled. The military offers allowances for food and off-base housing for officers who choose not to live on base according to the cost of living in the area. All these factored in with the enlistment bonus and bonus received for graduation of Officer Candidate School, the bottom line take home pay is in some cases higher in the military.

Salaries for the officers interviewed ranged from $2500 to $4500 dollars a month not including any bonus money or living allowances. These are easily comparable to high end salaries of the private sector. All of those who were interviewed that had outstanding loans said that their federal loans had all been paid off by the government, minus interest payments. Of those who wanted to further their education, they unanimously agreed that they would do so through the Army and their educational assistance programs.

There are other financial benefits provided by the military or the government for servicemen not included in this study. For example, preferential tax treatment for certain pay, use of the base commissary, and pension benefits were not considered. Inclusion of an analysis of these benefits would further clarify the relative financial benefits for military versus private industry careers for college graduates.

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ASSOCIATING BEHAVIORAL FINANCE TECHNIQUES WITH GAMBLING

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ABSTRACT

Behavioral finance is an emerging field that uses psychological theory to explain economic behavior. Behavioral finance principles have been used to explain stock market anomalies and other occurrences that cannot be explained by the classic assumption of rational behavior, maximizing return for a given level of risk or minimizing risk for a given level of return. This paper explores the application of behavioral finance theories to the gambling industry. Fieldwork at casinos, documented in a journal of observations about the gambling participants and the environment, provided data for analysis. As a result of this study, both gamblers and casino management may become more cognizant of the principles used to influence gambling behavior.

Keywords: anchoring, behavioral finance, casinos, framing, gambling

I. INTRODUCTION

The gambling industry has become a major provider of recreation in the U.S. Gamblers have "reported that they gambled for fun, to win money, or they were looking for excitement and a challenge" (Reardon, 1995). When people gamble, they gain enjoyment out of playing and winning. Losing is all part of the sport however, with both financial and psychological effects.

Gambling is a way for states to gain an easy ticket to tax money. States sponsor their own lotteries to support taxes, "In Fiscal Year 2004, lotteries generated over $48 billion in consumer spending, up from almost $45 billion in Fiscal Year 2003. Slightly over half of the money spent is returned to players in the form of prizes. Part of the remainder covers operating costs… the rest is transferred to state coffers. The states call their portion "profit," … it is actually tax revenue" (Hansen, 2005).

Casinos also provide significant tax dollars to the states. When people gamble in casinos, on average they lose more money then they win, keeping these casinos in business. Taxes are imposed on casinos, and the more loss the customer has, the more money the casino earns, with a portion directed to the government.

The gambling industry provides training and employment for otherwise unskilled people. When asked how many people work in casinos, the answer for Las Vegas is as follows: "It varies, according to the size of the casino. Binion's Horseshoe employs 2,600; Caesars Palace 4,000; and the MGM Grand has a work force of 7,000 people! Twenty-seven percent of Las Vegas' 570,000 employed people work in casinos" (Vinson, 2000).

Gambling can lead to many problems with families and friends due to people who lack the ability to quit while ahead or to cut their losses. "The urge to gamble becomes so great that the tension can only be relieved by more gambling. Higher stakes and personal risks become involved, as well as neglect of other interests, family, and work. Severe family problems, financial ruin, and criminal behavior to support the habit may result" (Compulsive Gambling, 2002). Some people gamble away their house, cars, and money they have saved for their families. Many wives/husbands will leave their spouses because of such a problem and threat to the welfare of the family.

Some financial success of casinos may be due to the effective use of behavioral finance techniques. Behavioral finance is an emerging field that uses psychological theory to explain economic behavior. Behavioral finance principles have been used to explain stock market anomalies and other occurrences that cannot be explained by the classic assumption of rational behavior, maximizing return for a given level of risk or minimizing risk for a given level of return. These techniques have been used to explain price movements in the stock market as well as to explain decisions made by corporate managers.

This study is an exploratory ethnographic study to explore the application of behavioral finance techniques in casino management. As a result of this study, both gamblers and casino management may become more cognizant of the principles used to influence gambling behavior.

II. LITERATURE REVIEW

"Behavioral finance is the study of the influence of psychology on the behavior of financial practitioners and the subsequent effect on markets" (Sewell, Martin, 2000). The area attempts to determine why people make irrational decisions when investing and spending money.

One principle of behavioral finance is ***framing***. "Framing is a cognitive heuristic in which people tend to reach conclusions based on the 'framework' within which a situation was presented"(Shefrin, 2000). For example, an investor may choose one investment when the potential returns are emphasized, while choosing a different investment if risks are presented more prominently.

Anchoring is a behavioral finance principle that suggests decision-makers may rely heavily on particular prior or current experiences while ignoring other experiences. For example, an investor might decide never to invest in the stock market again following one unfortunate stock pick, despite having received acceptable or better returns on other stocks.

A third behaviorsl finance principle relates to ***anxiety***. "Anxiety (conscious or unconscious) appears to accompany each investment decision. Anxiety manifests itself in multiple ways: It may appear as irritability, shifts in tone or posture, difficulties in communicating, or physical manifestations such as tremor, a lump in ones throat, or a sinking abdominal feeling (Lifson-Geist,1999)." These feelings could result in feeling pressure to make a quick decision, and a resulting rash investment decision.

Another behavioral finance principle relates to ***time***. "Time is both an objective and a subjective phenomenon. Objectively time can be defined as the duration of seconds, minutes, hours, days, months, years, and so on, that can be clocked and measured according to some agreed-upon standard (Lifson-Geist, 1999)." Although time is measured in uniform standards of measure, various factors can affect the perception of time passing. For example, studies have shown that environmental characteristics as well as mental health can influence the perception of the passage of time (Poole, 2001).

This section has presented examples of behavioral principles that have been introduced to the disciple of finance. These principles have been applied in finance to explain behavior that is not consistent with rationality, which finance theorists define as trading off return maximization and return minimization. This study is the first to explore the application of these principles specifically in the gambling industry.

III. METHODOLOGY

This exploratory ethnographic study was conducted on the floor of several Northeast casinos during November 2006. Visits took place on three separate occasions where this researcher spent 4 or more hours at the site. Because of the nature of the environment, specific rules were imposed on the researcher. For example, access to cell phones or other electronic devices, or note taking implements were prohibited.

The researcher observed the behavior of accompanying colleagues as well as all other participants in the casino. Environmental characteristics were also observed. The researcher took part in the gambling experience for pre-arranged period of time. Field notes were documented periodically during the casino visit by occasionally leaving the casino environment and note taking in the car.

For the sake of disclosure, the researcher is providing a description of himself and his own gambling history. I have a lot of fun gambling, but because I have an addictive personality, going to the threshold of the casino is usually a negative. Since I was 18 years old, four years ago, I have been gambling. I have gambled on the internet, in nice casinos, and at small-time slot machines in Texas gas stations. A gambler's attitude has become a big part of my life, from gambling with the stock market to gambling with deciding which highway to travel on.

IV. RESULTS

A major aspect of ***framing*** was the distancing that the casino makes between real dollars and gambling money. Real money is not exchanged on the floor, but rather is used to purchase chips at a convenient site on the periphery of the gambling area. Gamblers can use their credit or debt cards to purchase chips, and ATMs are also easily accessed. The chips do not resemble dollars or coins, which may help the casino frame the chips as gambling tools rather than representations of actual funds.

The financial aspect of gambling is downplayed in the casino. Signs regarding money around the casino are very small. Likewise, signs indicating the prices of the tables were also small, making it easier to focus on the action rather than the dollars.

The local casinos also promote the professional appearance of gambling. The environment is pleasant, relaxing, and the staff behaves professionally and courteously. This helps the gambler to view the environment as a relaxing, culturally acceptable, maybe even classy, activity.

The appearance of ***anchoring*** was clear at the craps table. People wanted to play at tables where others were winning thinking they will win if the people around them are winning. However, of course if you were winning at one point doesn't necessarily mean you will win again. Gamblers who assume they are on a roll are relying on chance and not on the possibility of loss and/or gain. A person may also sit down at a game not to enjoy the challenge of playing but rather to recover losses. Another form of anchoring is when a customer decides to walk in to a casino and sit down at the table; they may play blackjack based at a specific table based on how many people have sat there and played, but not necessarily rely on the statistical approach that odds are with the table, not with you.

During my playing time, I became aware of my own anchoring, relying on my current wins or losses for decision-making. I noticed that when I played blackjack and was winning, I would up my bets based on my recent success. As I began to lose big time, hand after hand, my bets decreased so that I could stretch out my remaining chips. I finally stopped when I was up $100 altogether.

Despite the relaxing environment, ***anxiety*** was clearly present in my observation. Gamblers made snap decisions rather than deliberating over odds and returns. Even though many participants consider gambling fun, and it certainly was a voluntary undertaking, most gamblers, especially those at the slot machines, sat expressionlessly except when they received a pay-off.

Regarding ***time***, we had gone into the casino with the agreement that we would leave together at a time appropriate for all of us. There were no time pieces displayed and it was impossible to determine whether it was dark or light outside. When we exited the casino we all looked at our phones and noticed it was 4:30am, much later than our estimate! With subjective time, we had no urgency to leave because we didn't realize how much time has gone by. Our perception of time had been distorted by the environmental distractions, our excitement and anxiety, and the absence of time pieces.

V. CONCLUSION

Based on the exploratory observations in this study, it appears that casino operators have put into practice behavioral finance techniques to facilitate the desire to game in their casinos. Application of these principles has resulted in the creation of an environment where:

- Playing chips are detached from their underlying dollar value.

- Success is visible, providing an anchor that attracts others and motivates them to participate.
- Anxiety speeds decision-making, increasing the number of transactions.
- Time is suspended.

Cognizance of these techniques has somewhat affected the attitude of this researcher, although it will not discourage me from taking part in this activity. Advice to casino gamblers is that they also look around and become aware of the application of these techniques and how they influence their behavior.

- Be aware of the reality of the money at risk, not just the chips, and the financial consequences of losing.
- Avoid basing decisions on recent history or others' successes.
- Slow down and do not succumb to the demand for snap decisions that ignore financial consequences.
- Be aware of time distortions; periodically check the time to avoid over-staying and over-playing.

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Available on request from the author or faculty advisor.

FINANCIAL PERCEPTIONS AND BEHAVIORS OF YOUNG COLLEGE INVESTORS

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ABSTRACT

As the variety of financial choices available increase, making investment choices is becoming increasingly complex. College students will soon be faced with making these important choices as they graduate and begin their careers. In this paper, we explore the personal investment perceptions and understanding of students at a northeastern university. As a result of the study, we will have greater understanding of how students today perceive their investment futures and their investment decision-making.

Keywords: college students, financial education, investment decisions

I. INTRODUCTION

Great rewards and security can prevail when investing is done with awareness, education, and knowledge. According to a publication by the Securities and Exchange Commission, "Knowing how to secure your financial well-being is one of the most important things you'll ever need in life…. if you get the facts about saving and investing and follow through with an intelligent plan, you should be able to gain financial security over the years" (SEC, 2004). In short, the investing process affects everyone, and all individuals should be aware of its importance.

Financial experts believe that "the best time to learn about money is when you're young and still in school. Starting young lets you take advantage of the magic of compound interest" (SEC, 2005). Young investors have a long term period for fund accumulation and therefore a long time for their money to compound returns.

Investment decisions are different for different age groups, ranging from young children saving coins in their piggy banks, to workers funding an income after retirement. There are many other reasons to invest such as preparing for a large purchase such as a car or house, children's education, or retirement security. When college graduates begin their first jobs, they will be faced with investment decisions regarding their retirement plans at work. Additionally, they may have excess income after paying their living expenses that can be invested.

Experts suggest that young investors should assume more risk in their investments than older individuals. For example, "Young investors in their 20's should probably keep 90 percent if not all of 401(k) assets in a diversified mix of equities" (Lim, 2006). Young investors with few responsibilities are put in a unique investment position, "The fact is, your 20's are an ideal time to be betting on stocks. For starters, when you're young, you have little to lose" (Lim, 2006).

Young investors have years and years ahead of them to rebound if their losses end up out-weighing their gains. In observing the investment patterns made by some of graduate students surveyed, "about half invest through their jobs in 401(k) plans. The rest do it for fun or are into it because their parents have discussed it at home" (Jeremias, 2003).

With investment decisions looming as soon as they begin their careers, if not sooner, college students need to understand the fundamentals of investing. How young investors educate themselves in their financial choices is a question. With concern that "the average student who graduates from high school lacks basic skills in the management of personal financial affairs" (Jump$tart Coalition, 2006), this study addresses how students are educated about their actions and perceptions in the world of investing. This study also addresses how college students make financial decisions, such as their influences, goals, risk aversion, and financial needs.

As a result of the study, we will have greater understanding of how students today perceive their investment futures and decision-making. Our research can help advisors understand the assumptions, behavioral choices, and influences that college students encounter in their decision-making. We will also the students' confidence in their investment knowledge. Results may be helpful for revising or developing educational programs for this age group.

II. LITERATURE REVIEW

According to an article published in Bank Investment Consultant (2006), young investors are focusing on their finances at a much earlier age then generations before them. One reason for this is "young people today are making a lot more money than many of their parents did, who may have lived paycheck to paycheck, so they have more money to invest".

College students are grasping the importance of relying on investments made now in order to have financial sustainability in the future. In a study conducted by Diversified Investment Advisors, 94% of Generation Y investors said that it is important to save and anticipate for funding of their own retirement due to a lack of confidence in Social Security (Mincer, 2005).

This drive to invest that young people possess is a step in the right direction, but it is how they execute their goal that is the problem. It is increasingly apparent that many young individuals are overwhelmed and under-informed when it comes to planning their finances. Many employers who have given their employees more control in the retirement planning process "are now realizing that most employees, including some of their highly educated employees, have little or no financial education" (Patterson, 1997). Also, these employees are only investing about one-third of what they are actually permitted to invest into their 401(k) plans.

Not understanding the fundamentals of investing is associated with the need for more adequate education available to college students. A study evaluating the financial education available to young people found that "over 90% of the students reported that they were getting their financial education from family and friends" (Devitto, 1999). This suggests that formal education is not widely pursued when deciding on investment matters.

The same survey evaluated another method some young investors use to gather knowledge – the internet. The results of these evaluations still remained inadequate in providing knowledge. "While financial literature and educational programs for teens are readily available, many do not conduct surveys that try to match knowledge with behaviors" (Hogarth, 2002). Without the proper analysis to evaluate the success of these online tools, these websites are endangering their credibility.

With the rising number of college students being exposed to and actively planning their financial futures, more research is needed to accurately identify the perceptions young people have of the investing process and what sources are fueling this knowledge. Many studies performed address young investors perceptions of retirement planning, but few choose to examine other investment goals and strategies of these young investors and who or what influences them in their financial decisions. This study seeks to explore further the investment perceptions and behaviors of college students and to identify who or what is influencing them on these decisions.

III. DATA AND METHODOLOGY

In order to obtain relevant data to guide us in our research, a survey data collection method was used. The survey was handed out to students in 2 independent business classes at the University. The students completed the survey in class. A total of 49 surveys were completed and returned. The survey was broken down into five sections, consisting of questions regarding demographics, students' financial obligations, financial goals, how educated they felt in the area of personal finance in comparison to their peers, how they felt they compared in relation to their peers in terms of their amount of investing, what investments they currently had or were held in a trust for them, how the University could better aid students in the field of personal finance, how confident they are in choosing certain financial instruments to invest in, how they make their investment decisions, how they plan to finance their retirements, and other general financial behavioral questions. Data collection took place during November of 2006.

The survey consisted of 18 questions, with 15 of these questions using a Likert-type scale. When this type of question was used, the scale ranged from not at all to very, or not confident to extremely confident, depending on the question. Students also had to rate data in order of importance. Four open-ended questions were provided to allow students the opportunity for further elaboration. The complete survey is available from the faculty advisor of this study.

Of the 49 completed surveys, all participants indicated that they held at least one form of investment. This sample consisted of undergraduates mostly with majors inside the School of Business, from Business Management, Marketing, Finance, and International Business to a few majoring in Construction Management as well as Legal Studies and Psychology. Most of the students were from New England, along with some representation from states such as North Carolina, South Carolina, and New York.

Respondents received extra course credit for their participation. To receive the extra credit, students signed an informed consent form. They were informed that completion of any or all of the survey was optional, and they handed in their survey separately from the signed informed

consent form. There was no correlation between the amount of extra credit students received and the level of participation in the survey.

IV. RESULTS

Participants ranged from the Sophomore to Senior level. The majority (84%) were Juniors, with seven Seniors (14%) and only one Sophomore (accounting for 2%). The survey was open to all students belonging to any school within the University. However, as a result of the survey being conducted in two Business classes, 94% of participants had at least one major within the School of Business. The other 6% consisted of 4% within Engineering and 2% in Liberal Arts.

In the second section of the survey pertaining to personal finances, 55% had reported never taking a class in personal finance or personal investing. Within the remaining 45% who had taken such a class: 72% reported taken a personal finance or personal investing class in college, with 16% taking this type of class in high school, and 12% took the class as a requirement for their area of study.

With regards to financial independence, it is quite surprising that only 69% of students surveyed balance their own checkbook. This is even more astonishing after taking a closer look: it is evident that the 31% who do not balance their own checkbook are all upperclassmen with a major inside the School of Business. This implies that these students have already completed the introductory accounting and management courses required by Business majors and have learned the necessary quantitative skills similar to that of balancing accounts. Only 14% file their own taxes. Of the participants, 71% reported having a credit card, but a refreshing less than half (37%) owe money on it.

The participants in the survey were asked to rate a series of financial obligations in order of importance. The following were in the top three of the students' rankings: 26 students had investing and saving money within their top three ranking, 22 students placed shopping, entertainment, and leisure activities among their top choices, and making car payments rounded out the top three with 19 students placing that obligation in their top three. On the other end of the spectrum, an obligation to pay rent or a mortgage was least of the students picks and by far beat out any of the other obligations as least-important, with 17 students placing it last on the list. These choices are not surprising given that the majority of students reside on campus.

When asked what financial goals, if any, the participants had, it was interesting to see the range between long-term and short-term goals. Many focused on things such as getting an apartment after graduation, increasing their savings, or be able to pay off their student loans within a few years. Some students' goals were immediate, such as participant #46 who wants to "buy a snowboard pass and have money for Christmas" similar to another student who wants "to have enough money for holiday gifts and where I do not have to work over winter break". Some students took it a few months beyond that and are trying to save for a spring break. Other goals were aimed for the not-so-near future. Participant #23 has a very specific goal "for every dollar earned, save half and not touch it until I am 30 years old". Another long-term goal was a little less specific, with the hope to just become wealthy.

Most of the students agreed that personal investing is somewhat to very important at this stage in their life, with 92% responding within that range. None of the participants felt that they were very knowledgeable in the area of personal investing and three quarters of the students felt only somewhat to not at all knowledgeable in this area.

The participants were given a list comprised of 11 investment vehicles, and were asked to select which ones they held personally or were held in a trust for them. All but six students had their own savings accounts, followed closely with 42 students owning their own checking accounts. Bonds were the leading financial instrument that was held in a trust for the students, with 21 total. Eight students reported owning stocks themselves, which is interesting when looked at in more detail. Of these eight students, three of them reported their confidence in the ability to choose stocks was at the lower end of the spectrum, one being not confident at all and the other two between not confident and somewhat confident. All of these students did note later that they received advice and guidance from parents, relatives, employers, or professional financial advisors when choosing their investments. Of the participants, 69% reported that parents or trustees had a part in making their investment decisions.

Overall, students felt most confident when choosing checking or NOW accounts and savings accounts. Students reported that they feel the least confident when choosing limited or general partnership shares, with 63% feeling below somewhat confident.

In respect to the confidence level participants had of Social Security being around to help aid in their retirement planning, only 3 students felt above somewhat confident. With students not planning on Social Security being around for their generation, 88% of those surveyed hope to rely on personal investments made during their career along with an 78% relying on an employer retirement plan in order to be financial stable when retiring. This is quite interesting because most students surveyed are planning to rely on their personal investments to retire, while the lack of confidence in being knowledgeable about investing if extremely prevalent.

V. CONCLUSION AND IMPLICATIONS

A further in-depth look at the financial perceptions as well as behaviors of college students was revealed as a result of this study. It appears that students are actively thinking about, if not engaging, in the investment process and attempting to prepare themselves financially for the future. With most of the participants in their last few years of college and getting ready for graduation, being knowledgeable in personal investing is increasingly important.

One major finding from this study is that most students feel that investing at this stage in their life is important, but the majority does not feel well educated on these choices they are confronted with in the investment process. This lack of knowledge is setting students back with their financial goals and may make investing very overwhelming for these individuals.
Many suggestions on how the University can better help aid students with personal financial education were revealed from this survey. Many suggested making an elective class geared towards personal investments, from balancing a checkbook to choosing the right 401K plans that

would be open to all University students. Others suggest going about teaching it in a different manner. Participant # 5 would like to learn "what we can do with less money", with many college students not having a surplus of money to invest. Another suggestion was to bring in guest speakers, provide more real-world projects, or offer seminars, such as those already offered at the University for study abroad programs or internship workshops. Others would like an even further-advanced education, such as having the University work with various companies to setup mutual funds or other ways to get students involved in hands-on investing.

After learning the outlook college students have on investing and the lack of confidence they possess in order to make well-educated investment choices, there is an evident gap in tools and resources available to them. It is apparent that students are seeking out ways to expand their knowledge and gain a better understanding in the area of personal investing, and the University should be driven to satisfy those needs.

In the past the University offered a one-credit personal finance class, which is not open to School of Business students. An upper level finance course in Personal Financial Planning will begin in the spring for business students. The University also offers a one-day long seminar: *Reality 101* for University seniors to help prepare them for life after graduation. Less than an hour of this seminar is focused on financial planning.

With this generation of college students soon to be faced with an increasing amount of investment decisions daily, it is necessary for these students to be aware and knowledgeable in the choices they are making in order to maintain financial sustainability for whatever their financial needs and goals maybe. It is important to note again that 88% of students surveyed plan on relying on their personal investments to retire on, yet the lack of confidence in making those investments is extremely low. Education and hands-on experience needs to be available somewhere along the road for these young investors to insure financial security. Implementing a more comprehensive way to educate students about choices they will be facing is an important component to allow for the success of any student and will lead to students having more confidence in their investment choices and decisions. Students need and deserve the right to access this knowledge from their University in an effective and applicable manner.

One limitation of this study is the assumption that education alone is a factor in confidence building. Research has established a link between experience and satisfaction with a financial decision (Poole, 1998). Whether experience is also a factor in confidence building has not been explored in the financial arena. The data suggest that further work is warranted given that the investment vehicles the participants were most confident about choosing were correlated with the investment vehicles that they actually held outside of trust. Clearly, further work is needed to explore more fully the relationship between actual experience and confidence and the role that educators can take in facilitating both knowledge acquisition and decision-making skill development.

REFERENCES

Available on request from either author or the faculty advisor.

AN ALTERNATIVE TO THE PURE DIVIDEND DISCOUNT MODEL

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ABSTRACT

The commonly used two stage dividend discount model used in various texts cannot be used for companies that pay no dividends or very low dividends such as Google. The problem is that the payout ratio is the same in both stages. A more flexible model, described in the classic text of Graham & Dodd which may be called the Molodovsky earnings multiplier model solves the problem, but leads to others.

One problem is finding an appropriate multiplier. We study multipliers and components back to 1926. Three recent complications have been caused by the unusual boom of 1995-2000, massive earnings measurement problems, and stock buybacks as a substitute for dividends.

INTRODUCTION

Why the Dividend Model Cannot Analyze Zero Dividend Stocks.

Exhibit 1 (Appendix) shows the Bourke Company example from (1, p. 322-3). Notice that Bourke's dividend of $2.00 appears in every term of the valuation equation 16 which Reilly & Norton [1] and Hooke [2] (R&N) have written out term by term. Now suppose that the dividend Do is zero as it is for Google. In this case all the terms are zero and the total value is zero.

The Bourke case is illustrative. On p. 490-1 (1) an actual company, Walgreen, is analyzed. See Exhibit 2 (Appendix). R&N did not write out the equation so we added it at the bottom of Exhibit 2, Equation 16. Also R&N did some rounding off. Taking the results to four places rather than two the value is $27.24 rather than $24.05. The initial dividend Do of $.17 appears in all terms. If the company had paid no dividends the equation would have calculated a value of zero.

R&N imply that a two stage model could have been used to analyze Walgreen but they chose to use three stage ramp model. We prefer an equivalent two stage model. A problem with a three stage model is that one has to pick two times, how long the first stage lasts and how long the second ramp down stage lasts. In the two stage model the job is cut in half since only the time for the first stage is needed. Exhibit 3 (Appendix) shows how the three stage model can be reformulated into an equivalent two stage model that gets the same answer. As can be seen in the exhibit the overshoot of the first stage is cancelled by undershooting the terminal stage at T = 9 years. The two stage equation is illustrated in Exhibit 3. The beginning setup is Equation 1. Factoring we get Equation 2. The terms in the brackets are geometric series. Closed form formulas yield Equation 3. This shows another advantage of the two stage approach. Calculations can be made much more quickly than the term by term method needed for the three stage approach. We get the same answer within a penny. The 4^{th} equation is the dividend model in symbolic form. The only variable that changes value is g, the growth rate. In Stage 1 it has the high growth value g. Then it declines to g_T in the terminal or 2^{nd} stage. R&N do not discuss how to find the terminal value of g in any detail. Since g_T holds in perpetuity it should not be larger than the long run growth of the economy or the market. If the company grows at say 8% in perpetuity and the economy only 6%, eventually the company would own the whole economy which cannot happen. This is discussed in detail below. The 5^{th} equation is the 4^{th} divided through by Eo to convert it into a P/E model. Do/Eo is the payout ratio POR. In this form the dividend model can be compared directly to the payout ratio multiplier model developed below. The two stage simplification does not solve the zero payout problem. The .17 dividend Do is in all the terms and if Do is zero the function gives a zero valuation as above.

A SOLUTION

The problem with the pure dividend models is the implicit assumption that the payout ratio does not change. If the initial dividend is zero it (and the payout ratio) stays at zero, even when the growth rate changes. Hence, Equations 4 and 5 in Exhibit 3 would give Google a value of zero. Ten years ago Microsoft was in Google's position today, no dividends and no intention to start. Despite Microsoft's attempts at denial (when a "growth" company starts paying a dividend it is considered by many that the company is no longer the growth company it was in the past) Microsoft finally caved in under pressure to pay a dividend. Someday the same pressures will affect Google. What we need to ensure non-zero valuation is a model that allows the payout ratio to change.

The Payout Multiplier Model – The Role of the One Stage Model.

The one stage, or constant growth (Gordon) model: $P = D1 / (k–g)$ [forward version] or $P = Do (1+g) / (k–g)$ [TTM version] are standard in virtually all finance texts. Because the growth of the average stock or the market average g_M is less than k_M , the market discount rate the model does not go to infinity as it does when $g > k$. Hence we can use the one stage model to estimate the P/E of the market. The TTM one stage model is converted into a P/E model by dividing both sides by Eo, the earnings per share of the most recent 12 months: $P/Eo = Do/Eo (1+g) / (k–g)$. But Do/Eo equals POR, the payout ratio. Hence $P/Eo = POR (1+g) / (k–g)$. If we use market values for the variables: POR_M being the payout ratio of the market average or of the average stock, k_M being the discount factor for the market, and g_M being the growth rate of the average stock, the equation becomes: $(P/Eo)_M = POR_M (1+g_M) / (k_M–g_M)$. This function is important because it is part of the, payout ratio earnings multiplier alternative model. We now can construct the two stage P/E model with a flexible payout ratio (which is described in G&D (3, p. 528-9).

The Payout Ratio Model.

In the dividend model (Equation 5 of Exhibit 3) the only variable that changes value from stage 1 to stage 2 (in Year 9) is the growth rate from g (.13) to the terminal stage growth rate g_T (.08). The discount factor k does not change nor does the implicit payout ratio. In the payout ratio model it is assumed that the high growth characteristics of the company hold only through the first stage. In the second stage it is assumed that the company has matured and become an average company with the characteristics of the market average. In the first stage, the growth rate is g, the discount factor k and the payout ratio POR. In the second stage, the growth rate declines to the market growth rate g_M, the payout ratio increases to the market payout ratio POR_M, and the discount factor changes from k to k_M. G&D (3, p. 450-1, 514) recommend that the high growth Stage 1 projection be limited to four years. Hence in this model T = 4.

The payout ratio model is developed in Exhibit 4 (Appendix).. The first line is the traditional setup with one modification. In year 5, the first year of stage two, it is assumed that the discount rate changes from the company value to that of the average company. Line 1a is most important. In Stage One the dividend payout ratio is POR which for a high growth company such as Google currently may be zero. In Stage Two the company is assumed to have the payout ratio of the market average POR_M. It is this assumption that gives the model the ability to value such companies as Google. If POR is stuck at zero then the model cannot give Google a value. In Equation 2, line 2, the terms in line 1a are substituted into line 1. Equation 3, line 3 factors out the POR's which now are different in the two stages. Equation 4, line 4 calculates the growth of EPS which is at the rate of g in the first stage and slows to g_M in the second stage, analogous to the assumption in the pure dividend model. More substitution and factoring produces the bracketed series in Equation 5, line 5, a geometric series with the closed form formulas, of line 5a. Equation 6, line 6, shows the function in closed form.

A Direct Comparison of the Models.

Equation 5 of Exhibit 3 (reproduced as Equation 1 below) shows the P/E version of the pure dividend discount model. Equation 6, of Exhibit 4, (reproduced as Equation 2 below) shows the change in payout ratio model.

$$P/Eo=POR\ (1+g / k–g)\ [1 – (1+g / 1+k)^T]+POR\ (1+g_T / k–g_T)\ (1+g / 1+k)^T \quad (1)$$

$$P/Eo=POR\ (1+g / k–g)\ [1 – (1+g / 1+k)^T]+POR_M\ (1+g_M / k_M–g_M)\ (1+g / 1+k)^T \quad (2)$$

The stage 1 portions are identical. The crucial difference is the payout ratio in the second stage. In the dividend model POR is frozen at the first stage level and if the first stage level POR is zero so is the second stage. In the payout model POR_M becomes that of the market. This allows the second stage to take on positive values. Both models assume that the high growth rate g declines to a terminal value. R& N's terminal value permanent growth rate to infinity g_T is .08 for Walgreen. We believe that .08 is higher than the permanent growth rate g_M of the economy which historically has been about 6% which in economic terms is a fallacy of composition overestimate. The growth rate of the economy is studied below. The last difference is that the discount rate stays at k in the dividend model and changes to k_M in the payout model.

The Market Multiplier Version.

The theoretical value of the market multiplier was found to be:

$$(P/Eo)_M = POR_M\ (1+g_M) / (k_M–g_M)=MM \quad (3)$$

This set of terms is in equation 6 of Exhibit 4. Substituting gives Equation 7 of Exhibit 4.

The next step involves matching the Equation 7 to Molodovsky's Procedure in G & D. If we multiply Equation 7 of Exhibit 4 by Eo and substitute Do for POR Eo we get:

$$P = Do\ (1+g / k–g)\ [1 – (1+g / 1+k)^T] +MM\ Eo\ (1+g)^T / (1+k)^T \quad (4)$$

Equation 4 above describes the Molodovsky (editor of Financial Analyst's Journal 1964-69 and pioneering securities researcher) step by step procedure in G & D (3, p. 528-9). Molodovsky used T = 10 years in his example. In Step A he assumed tenth year earnings of $2 per share $[Eo(1+g)^T]$. This is multiplied by a market multiplier MM of 13.5 giving a future value of $27. The discount factor assumed is 7½% giving a present value factor of $1/1.075^{10}$ = .4852. $27 x .4852 = $13.10. In Step B Molodovsky approximates the present value of dividends and gets $6.30, using the first stage term with g = .072 yields an answer of $6.08. Step C adds the answers of A and B. Molodovsky got $19.30 as the value of a share, our equation gets $19.18.

DEVELOPING THE PAYOUT OR MULTIPLIER MODEL TO ANALYZE GOOGLE

We can use either Equation 6 or Equation 7 from Exhibit 4 to analyze Google. Since the current POR is zero Stage One in both equations is zero and the equations are simply:

$$P/Eo = POR_M\,(1+g_M) / (k_M - g_M)\;\;[1+g/1+k]^T \quad (5)$$

$$P/Eo = MM\;\;[1+g/1+k]^T \quad (6)$$

The easiest equation to use is 6. "All" that is needed is an appropriate market multiplier, perhaps modified by sector characteristics (for example, homebuilders tend to have P/E's about half the market or even less). In Chapter 37 on The Capitalization Rate for Earnings and Dividends, G&D (3) have two suggestions for finding the multiplier of the market. The first is examining the historical record. The second is their "central value" approach which bears a resemblance to the "Fed" model of Alan Greenspan.

Table 1 shows G &D's historical P/E data for the Cowles-S&P Index from their Table 37-1 to 1960 along with our summarized updates.G&D found a P/E of 13.6 for the period 1871-1960. Continuing their table we find that the average P/E from 1960-1994 was 14.76. A problem is caused by the period 1994-1999 which took the P/E to unprecedented heights. Alan Greenspan said the market suffered from "irrational exuberance" in December 1996 and many consider that this period was a stock market "bubble". Also it is almost certain that the earnings for this period are overstated and P/E's understated. Liesman and Weil in the July 13, 2001 Wall Street Journal (5) note that the "idea that prior profits have been overstated helps economists explain what to them was one of the mysteries of the late 1990s. Generally, corporate profits have grown in line with the economy. For the past five years, however, S&P 500 profits have expanded about twice as fast as the economy's total output."

Table 1: PIE for Cowles - S & P

Years	P/E	Years	P/E
1871-80	11.2	1960-72	17.85
to 1890	16.0	to 1982	9.26
1900	16.1	1994	16.25
1910	13.2		
1920	9.7	1960-94	14.76
1930	11.0		
1940	16.3	1995-99	24.96
1950	9.7	to 2004	25.19
1960	13.2		
		2005	17.85
1871-1960	13.6	Jun 2006	17.05

They note that write offs for the six month period ending March 31, 2001 were the highest by far for any such period. The implication is that the huge write offs meant that past profits had been overstated. The accounting problems and controversies were so severe that Standard & Poor's felt compelled to develop a new concept called "core" earnings in a release of May 14, 2002.
Earnings controversies continue. There are GAAP earnings, operating earnings, core earnings, company "pro forma" earnings (see Google, SanDisk, QLogic, etc. press releases), and other

analyst (First Call, etc.) earnings. And now we have the stock option backdating scandal. We consider the high P/E 1994-2004 period to be an abnormal period, an outlier that should be disregarded. It appears from 2005 data and the first half of 2006 that we have returned to a more normal P/E, the most recent being 17.05. If we ignore the abnormal 1994-2004 period the long run P/E over 124 years (2004-1871 + 2005) is about 15 which is exactly what G&D found in their 1962 book p. 511.

G&D's second method of finding a market multiplier is their central value method. Originally it was (S&P data): $P = EPS / 2\ i_{AaaMoody's}$ where the interest rate is the 3 year moving average rate on Moody's Aaa bonds. It was modified to $P = EPS / 1.33333\ i_{Aaa}$ in their 4th Edition. Dividing by EPS and inverting we get $E/P = 1.333\ i_{AAA}$. E/P is the earnings yield. The implication is that if the earnings yield is greater than 1 1/3 the Aaa rate the market is undervalued. If E/P is less than 1.333 times the Aaa rate the market is overvalued. And if E/P is equal to $1.333\ i_{Aaa}$ the market is fairly valued. As of June 2006 the 3 year Aaa average was 5.5075% implying a fair value E/P of 7.3433% and a P/E of 13.62.

This model is quite similar to the "Fed Model" popularized by Alan Greenspan in 1997 which compares the earnings yield (E/P) of the S&P to the yield on the 10 year Treasury Bond. As above, if the earnings yield is greater than the yield on the 10 year bond the stock market is undervalued, etc. With the 10 year Treasury at 4.60% the fair value forward P/E is 21.74 (Note: The 12 month earnings for the S&P in September 1929 were $1.63, the index 31.30 for a P/E of 19.20). The conclusion is P/E from the Fed formula is too high.

Another approach is to estimate the parameters of the one stage model: $P/Eo = POR_M\ (1+g_M) / (k_M - g_M)$. The data appendix has S&P yearly data from 1926 (we intend to redo this work with quarterly data. Another future research project is to use "real" or inflation adjusted data). A condensed summary is shown in Table 2.

Table 2: One-Stage Model Results

Year	P/Eo	DivYield	POR_M	$_{End}EPS$	g_M	Implied $(k_M - g_M)^*$	
1925				1.22e			
1926-29	14.855	4.228%	61.715%	1.61	7.180%	4.453%	
1930-39	16.523	5.675	90.106	.90	–5.650	5.153	
1940-49	10.933	5.719	59.366	2.32	9.932	5.969	
1950-60	12.847	4.610	55.025	3.27	3.169	4.419	
1961-72	17.847	3.121	55.337	6.42	5.783	3.280	
1973-82	9.262	4.344	43.045	12.64	7.009	4.973	
1983-94	16.247	3.430	53.757	30.60	7.646	3.562	
1995-99	24.962	1.662	39.504	48.17	9.499	1.733	
2000-04	25.190	1.518	38.126	58.55	3.980	1.574	**2.24

2005	17.850	1.780	31.774	69.93	19.436	2.126	**3.63
Jun 2006	17.050	1.845	31.467	74.49	13.467	2.094	**3.68

* equals $POR_M (1+g_M) / (P/Eo)$. **with buyback adjustment from Table 3.

The "Bubble" and Other Problems.

It is evident from the table that the 1995-2004 behavior was quite different from the preceding seven decades (and even back to 1871 from the G&D Cowles Commission P/E data). One cause is the bubble which raised P/E's to historic heights. But this does not account for the decrease in the payout ratio. There are perhaps four reasons why the payout ratio has decreased.

The first reason was tax efficiency. When the tax rate on dividend income exceeded the rate on capital gains it was cheaper for the company to distribute funds by buying back stock rather than paying dividends. A fairly well known case (6, CFO Magazine April 2001, Alix Nyberg) is that in 2001 when the CEO of Ultramar Diamond Shamrock announced a stock buyback financed by a dividend cut the stock rose 4% immediately.

The second reason stock buybacks are a good substitute for formal dividends is that buybacks are flexible. An increase cash dividend is considered to be a commitment to maintain it in the future and cuts, if not done for the Ultramar reason, may lead to the stock being punished. Stock buybacks do not necessarily promise a long term commitment and can be discontinued. Stock buybacks for these reasons should count as dividends.

There is a third reason for stock buybacks. Executive stock option grants have increased shares outstanding for many companies substantially. Frequently companies buy back stock to reduce the dilution caused by the stock option programs. These repurchases are not dividends but an indirect recognition of executive pay.

The Senior Index Analyst at Standard & Poor's, Howard Silverblatt [4] has been concerned about the dividend yield and payout problems. The pioneering article of S&P is (7, "Buybacks and the Impact of Share Count Reduction", March 24, 2006). Plus two articles (8, "S&P 500 Buyback Activity Continues ", June 12, 2006) and (9, the buyback section of "Record Company Cash Levels Producing Significant Interest Income", May 24, 2006). The articles contain S&P buyback data identified in Table 3 along with our adjusted payout ratios for 1999-2005 (we are hoping to get more buyback data from S&P back to at least 1993).

The "new" idea of S&P is to consider that buybacks are dividends in disguise. In the May 24 article dividends and buybacks are added together and the combined dividend and buyback yield calculated. Similarly we combine dividends and buybacks to get the combined dividend and

buyback payout ratio in Table 3. There are two problems, one minor and one major. The minor problem is the set of accounting problems particularly write-offs that plague the "As Reported Earnings" (GAAP) numbers especially hard in 2001-2. Accordingly we use adjusted operating earnings as a replacement for the GAAP numbers (378.64 replacing 253.50 for 2002 and 313.87 replacing 222.74 for 2001) as calculated in the footnote. Without this adjustment the 2001-2 results are junk outliers.

The major problem is that the combined dividend buyback payout ratio (POR Div+BB) is far too high with values higher than all 1926-94 periods except the Great Depression. Counting all buybacks is "overkill". But some buybacks should not be counted. Stock bought back to counter the dilution from stock option grants should not be counted as dividends since that is essentially an indirect payment to management for services rendered. Silverblatt mentions that some shares are accumulated for mergers and acquisitions, and these repurchases should not be counted as dividends either. The June 12 article states that "the issuance of shares to cover employee stock options is still a major component of buybacks". It would be nice to have the percentages of buybacks due to stock option activity, mergers, and dividend substitutes available but unfortunately such data is not available currently. Accordingly we make a simple assumption, that the major component of buybacks due to options as well as potential merger activity is 60% of buybacks leaving 40% as a dividend proxy. The column POR Div+.4BB is the payout ratio measured as dividends plus 40% of buybacks divided by the As Reported Earnings (which is the series that goes back to 1926 and before).

Table 3: Buybacks and the Adjusted Payout Ratio
S&P Data (website and articles)

Year	Dives $b	Buybacks	Div+BB	Div+BBYield	DivYield	BuybackYield
Jun06	212	403	614	5.34%	1.84%	3.50%
2005	202	349	551	4.90	1.79	3.11
2004	181	197	378	3.35	1.60	1.75
2003	161	131	292	2.84	1.57	1.27
2002	148	127	275	3.39	1.83	1.56
2001	142	132	274	2.62	1.36	1.26
2000	141	151	292	2.49	1.20	1.29
1999	138	141	279	2.27	1.12	1.15

Year	MarketVal	OpErns	AsRptdErns	POR Div+BB	POR Div+.4BB
Jun06	11497	737	672	.91369	.55536
2005	11255	694	634	.86909	.53880
2004	11289	630	545	.69358	.47670
2003	10286	505	450	.64889	.47422
2002	8107	423	379a	.72559	.52454
2001	10463	351	314a	.87261	.62038

2000	11715	487	433	.67436	.46513
1999	12315	426	397	.70277	.48967
1998		352	300		
1997		340	306		

Year	P/E	g_M	$(k_M–g_M)$
Jun06	17.10	13.467%	.0368
2005	17.74	19.436	.0363
2000-04	25.07	9.499	.0224
1999	31.01	3.980	.0164

a Equals operating earnings times .89477, the average relation 1997-2000 and 2003-Jun06.

Summarizing the Historical Data for the $POR_M (1+g_M) / (k_M–g_M)$ Approach.

Using the adjusted data and even counting the .0224 value for 2000-4 the $(k_M–g_M)$ has a post 1960 value of about .0354 (the 1926-60 average is about .0508). The post 1960 payout ratio including the adjusted 2000-05 value of .51219 is about .50840. The compounded growth rate of EPS from 3.27 $(1+g_M)^{45.5}$ = 74.49 is .0711. Substituting into the function gives a market multiplier for the average stock of 17.67. Copying Graham & Dodd and Bernhard [4], we average this with the 15 from the historical P/E study to get an estimated market multiplier of 16.4. With the latest S&P P/E at 17.10 or so the market as of June 06 would appear to be near historic fair value. Note about k_M. If $(k_M–g_M)$ = .0354 and g_M = .0711 then k_M = .1065.

USING THE MULTIPLIER TWO STAGE MODEL TO ANALYZE GOOGLE

The pure dividend model gives a value of zero to Google because the current dividend is zero. But the multiplier model can be used. It is simple because the first stage is zero as shown in Equation 7.

$$P/Eo=MM\ [1+g\ /\ 1+k\ ]^T. \quad (7)$$

The first task is to pick an appropriate multiplier MM. If we were analyzing Lennar in the home construction business and use the 16.4 multiplier we would find it a super buy because it has a current P/E of only 5.35 (industry 5.00) and for all reasonable values of g, k, and T the formula gives a higher value. The 16.4 is for an average stock in average times. Industry characteristics must be taken into account. As for Google it is a unique company. Its only real competitor at the moment is Yahoo which has a P/E of 29.8 at this time (Yahoo Finance has an industry P/E of 41 but who else is in the industry?). G&D have a comment about P/E targets for individual stocks, p. 514. An upper limit would be 20 times earnings 4 years hence. Judgment is used to set the multiplier between 7 and 20. Being conservative let us say that even Google does not

deserve a 20, let us use 19. Setting T. R&N used 9 years for Walgreen. G&D set T at a maximum of 4 as mentioned several times above. As an experiment we will try T = 9 to see what happens. Then we will use T = 4.

Finding k. We use the security market line approach where $k = k_{rf} + [k_M – k_{rf}]$ Beta. Above we found k = .1065. Many analysts use the rate on the 10 year Treasury for k. It is .0463 currently (Oct. 1). Yahoo Finance gives Google a beta of .66, Reuters .89. Being conservative we use Reuters. Hence k for Google is estimated to be .0999.

Finding g. Google's sales and EPS growth rates have been in the 70-90+% range but let us assume 55%. Eo= 6.85. Using T = 9:

$$P/6.85=19\ [1.55 / 1.0999]^9 \qquad (8)$$

$$P = 2852.66$$

T = 9 gives an answer reminiscent of the dot.com days of 1999. Using T = 4 gives a fair value price of $513.28.

The Impact of Excluding 1994-04 Data.

If we had included the bubble, aftermath, and accounting problem years 1994-04 in the analysis the historic multiplier would have been about 18 rather than 16.4, a difference of 1.6. If we increase Google's multiplier proportionally by the same amount it becomes 20.85 and Google's estimated fair value becomes $567.26. This is an aggressive estimate. The $513.28 estimate is more conservative. In general there are costs of being too conservative or aggressive. If an investor is too conservative or selective stocks that go up will not be bought, an opportunity cost. An aggressive investor will buy more stocks that go down. This situation is similar to the Type I and Type II errors in sampling theory.

XTO ENERGY

This is a company with dividends but the payout ratio is only 6% or .06. It gives us a chance to compare the results of the pure dividend model versus the multiplier model.
Parameter values: Beta = .94 giving a k of .1029. Growth g is measured by projections of real product production of natural gas of 21% which it has been doing for the past decade. The value of the first stage of both models is shown in Equation 9.

$$.06\ (1.21 / [.1029 – .21])\ (1 – [1.21 / 1.1029]^4) = .3042 \qquad (9)$$

The Multiplier Model Result.

The industry multiplier is less than 16.4 at 13.1 (Yahoo Finance). Natural gas being quite volatile to be conservative we drop the multiplier to only 9. The second stage is: (Equation 10)

$$9\,[1.21\,/1.1029\,]^4 = 13.039 \quad (10)$$

The estimated value is $P / 4.94 = 3042 + 13.039$. (11)

$P = \$65.91$

The Pure Dividend Model.

The second stage is from Equation 5 of Exhibit 3. It keeps the POR of .06. We assume a terminal growth rate of .0711. Substituting, we get Equation 12.

$$.06\,(1.0711\,/\,[.1029 - .0711]\,)\;(1.21\,/\,1.1029)^4 = 2.9279 \quad (12)$$

The estimated value is $P / 4.94 = .3042 + 2.9279$. (13)

$P = \$15.97$.

WALGREEN

R&N found a value of $27.05 (27.25 without rounding errors) using the dividend model. We use the following for the multiplier analysis. As R&N assume g = .13. They say that WAG deserves a premium multiplier, we agree so MM = 20 (even higher than Google). R&N assumed a risk free rate of .05 and a beta of .90 which, using $k_M = .1065$ gives a k of .05 + (.1065 – .05) .90 = .10085. Their 2004 Do was .17 and the implied Eo was 1.264 (it was 1.31 actually from the 2005 10K) giving a current POR of .1345. (k–g) = .02915. Then, per Equation 14:

$$P/1.264 = 1345\,(1.13\,/\,-.02915)\,[1 - (1.13\,/\,1.10085)^4] + 20\,(1.13\,/1.10085)^4 \quad (14)$$

P = $28.79 which is fairly close to R&N.

The pure dividend model can work for companies with a payout ratio in double digits, just not for zero payers like Google or nominal payers like XTO.

CONCLUSION

The pure dividend model cannot be used to analyze stocks with a zero or nominal dividend payout. The multiplier model redeveloped here is a general model capable of analyzing such stocks. Two stage models can give the same results as multistage models with fewer assumptions. Graham & Dodd [3] estimated a multiplier of about 15 for the average S&P stock. Our attempt to update their results gives a multiplier estimate of 16.4. G&D used data from 1871 to 1960 for their estimate. We included the years 1961-94 and 2005-06-midyear in our update excluding 1995-2004 which was distorted by the dot.com bubble and aftermath along with massive accounting problems. Excluding 1994-04 is a conservative assumption. There are two useful byproduct results. It is estimated that the historic value of $(k_M – g_M)$ is .0354. The terminal market growth rate g_M was estimated to be .0711. Combining these two estimates gives an estimate of .1065 for k_M which is a key number in the security market line equation. It appears that the market has returned to more normal levels in 2005-1H06. But one factor has

not, the dividend payout ratio. Silverblatt has created the dividend plus buyback yield which we transformed into a dividend plus buyback payout ratio and then modified that to a dividend plus .4 buyback payout ratio. More work remains to be done on this problem.

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APPENDIX

Exhibit 1: Bourke Company

Year	Dividend Growth Rate	Current Dividend D_o
1-3	25%	$2.00/share
4-6	20%	
7-9	15%	
10+	9%	

$$V_1 = \frac{2.00\,(1.25)}{1.14} + \frac{2.00\,(1.25)^2}{(1.14)^2} + \frac{2.00\,(1.25)^3}{(1.14)^3}$$

$$+ \frac{2.00\,(1.25)^3\,(1.20)}{(1.14)^4} + \frac{2.00\,(1.25)^3\,(1.20)^2}{(1.14)^5}$$

$$+ \frac{2.00\,(1.25)^3\,(1.20)^3}{(1.14)^6} + \frac{2.00\,(1.25)^3\,(1.20)^3\,(1.15)}{(1.14)^7}$$

$$+ \frac{2.00\,(1.25)^3\,(1.20)^3\,(1.15)^2}{(1.14)8} + \frac{2.00\,(1.25)^3\,(1.20)^3\,(1.15)^3}{(1.14)^9}$$

$$+ \frac{\dfrac{2.00\,(1.25)^3\,(1.20)^3\,(1.15)^3\,(1.09)}{(0.14-0.09)}}{(1.14)^9} = 94.21 \qquad (15)$$

Comment: This equation is crucial. It is direct evidence that if the dividend is zero (as it is for Google) instead of $2.00, the value is zero.

Exhibit 2: Walgreen Summary

Year	Dividend Growth Rate	Current Dividend D_o
1-7	13%	$.17
8	12%	
9	11%	
10	10%	
11	9%	
12+	8%	

$$P = .17\,\frac{1.13}{1.09} + .17\,\frac{1.13^2}{1.09^2} + .17\,\frac{1.13^3}{1.09^3} + \ldots + .17\,\frac{1.13^7}{1.09^7}$$

$$+ .17\,\frac{1.13^7\,1.12}{1.09^8} + .17\,\frac{1.13^7\,1.12\,(1.11)}{1.09^9} + .17\,\frac{1.13^7\,1.12\,(1.11)\,1.10}{1.09^{10}}$$

$$+ .17\,\frac{1.13^7\,1.12\,(1.11)\,1.10\,(1.09)}{1.09^{11}} + .17\,\frac{1.13^7\,1.12\,(1.11)\,1.10\,(1.09)\,1.08}{1.09^{12}}$$

$$+ .17\,\frac{1.13^7\,1.12\,(1.11)\,1.10\,(1.09)\,1.08}{1.09^{12}}\left[\frac{1.08}{.09-.08}\right] = 27.24 \qquad (16)$$

Exhibit 3: Two Stage Equivalent DDM Function

Years	3 Stage gr*	2 Stage gr	Overshoot
1-7	.13	.13	0
8	.12	.13	.01
9	.11	.13	.02
10	.10	.08	-.02
11	.09	.08	-.01
12+	.08	.08	.00

* = gr

$$P = .17\ \frac{1.13}{1.09} + .17\ \frac{1.13^2}{1.09^2} + .17\ \frac{1.13^3}{1.09^3} + \ldots + .17\ \frac{1.13^9}{1.09^9}$$

$$+ .17\ \frac{1.13^9}{1.09^9}\ \frac{1.08}{1.09} + .17\ \frac{1.13^9}{1.09^9}\ \frac{1.08^2}{1.09^2} + \ldots + .17\ \frac{1.13^9}{1.09^9}\ \frac{1.08^{00}}{1.09^{00}} \qquad (1)$$

$$P = .17 \left[\frac{1.13}{1.09} + \left\{ \frac{1.13}{1.09} \right\}^2 + \ldots . \left\{ \frac{1.13}{1.09} \right\}^9 \right]$$

$$+ .17\ \frac{1.13^9}{1.09^9} \left[\frac{1.08}{1.09} + \left\{ \frac{1.08}{1.09} \right\}^2 + \ldots . + \left\{ \frac{1.08}{1.09} \right\}^{00} \right] \qquad (2)$$

$$P = .17\ \frac{1.13}{.09-.13} \left[1 - \left\{ \frac{1.13}{1.09} \right\}^9 \right] + .17 \left\{ \frac{1.13}{1.09} \right\}^9 \frac{1.08}{.09-.08} = 27.23 \qquad (3)$$

$$P = D_o\ \frac{1+g}{k-g} \left[1 - \left\{ \frac{1+g}{1+k} \right\}^T \right] + D_o\ \frac{1+g_T}{k-g_T} \left\{ \frac{1+g}{1+k} \right\}^T \qquad (4)$$

$$\frac{P}{E_o} = POR\ \frac{1+g}{k-g} \left[1 - \left\{ \frac{1+g}{1+k} \right\}^T \right] + POR\ \frac{1+g_T}{k-g_T} \left\{ \frac{1+g}{1+k} \right\}^T \qquad (5)$$

Exhibit 4: Payout ratio model

$$P = D_1 \text{---} \frac{D_2}{1+k} + \frac{D_3}{(1+k)^2} + \frac{D_4}{(1+k)^3} + \frac{D_5}{(1+k)^4} + \frac{D_6}{(1+k)^4 (1+k_m)} + \frac{\ldots}{(1+k)^4 (1+k_m)^2} \quad (1)$$

$$D = POR\ E;\ D_2 = POR\ E_2 \ \ldots\ D_4 = POR\ E_4 \quad D_5 = POR_m E_5\ D_6 = POR_m\ E_6 \qquad (1a)$$

$$P = POR\ E_1 \frac{+ POR\ E_2}{1+k} \frac{+ POR\ E_3}{(1+k)^2} \frac{+ POR\ E_4}{(1+k)^3} + \frac{POR_m E_5}{(1+k)^4} + \frac{POR_m E6}{(1+k)^4 (1+k_m)} + \frac{\ldots}{(1+k)^4 (1+k_m)^2} \quad (2)$$

$$P = POR\ E_1 + \left[\frac{E_2}{1+k} + \frac{\ldots\ E_4}{(1+k)^2} + \frac{POR_m}{(1+k)^4} \right] E_5 + \left[\frac{E_6}{(1+k)^4(1+k_m)} + \frac{\ldots}{(1+k)^4\,(1+k_m)} \right] \quad (3)$$

$$E_1=E_o(1+g)\ E_2=E_o\,(1+g)^2\ldots E_4=E_o\,(1+g)^4\ \ E_5=E_o\,(1+g)^4\,(1+g_m)\ E_6=E_o\,(1+g)^4\,(1+g_m)^2 \quad (3a)$$

$$P = POR\ E_o\ \frac{(1+g)}{1+k}\left[1 + \frac{E_o(1+g)^2}{(1+k)^2} + \ldots \frac{E_o(1+g)^4}{(1+k)^4} + \frac{POR_m\ E_o(1+g)^4(1+g_m)}{(1+k)^4\,(1+k_m)} + \frac{E_o(1+g)^4(1+g_m)^2}{(1+k)^4\,(1+k_m)^2} + \ldots \right] \quad (4)$$

$$\frac{P}{E_o} = POR\ \frac{1+g}{1+k}\left[1 + \left\{ \frac{1+g}{1+k} \right\}^2 + \ldots \left\{ \frac{1+g}{1+k} \right\}^4 \right] + PORm\ \frac{1+g}{1-k}^4\ \frac{1+g_m}{1+k_m}\left[1 + \frac{1+g_m}{1+k_m}^2 + \ldots \frac{1+g_m}{1+k_m}^{oo} \right] \quad (5)$$

$$\left(\frac{1+g}{k-g}\left[1 - \left\{ \frac{1+g}{l+k} \right\}^4 \right] \right) \frac{1+g_m}{k_m-g_m} \quad (5a)$$

$$\frac{P}{E_o} = POR\ \frac{1+g}{k-g}\left[l - \left\{ \frac{1+g}{1+k} \right\}^4 \right] + PORm\ \frac{1+g_m}{k_m-g_m}\ \frac{1+g}{1+k}^4 \quad (6)$$

$$POR_m\ \frac{1+g_m}{k_m-g_m} = \frac{P}{E_{o\ m}} = \left\{ \frac{P}{E} \right\} \text{ of the market} = \text{market multiplier MM} \quad (6a)$$

$$\frac{P}{E_o} = POR\ \frac{1+g}{k-g}\left[l - \left\{ \frac{1+g}{1+k} \right\}^4 \right] + MM\ \frac{1+g}{1+k}^4 \quad (7)$$

THE EFFECT OF EARNINGS ANNOUNCEMENTS ON FIRM VALUATION

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ABSTRACT

This paper investigates the relationship between stock prices and earnings announcements. The empirical results indicate that the mean square excess return on the announcement day is larger than the average during the non-event period. A sample of 38 earnings announcements from third quarter earnings announcements of 2004 to second quarter of earnings announcements of 2005 are examined, of which 18 are good announcements and 20 are bad announcements. The results reveal that the average abnormal returns on announcements days are different than zero for each sample. These findings are consistent with the prediction that earnings announcements possess informational value.

KEYWORDS

Firm Valuation
Effect of Earnings Announcements

INTRODUCTION

Earnings are one of important accounting measures of firm performances. It provides the information of firm's profit or loss from business activities and events during a quarter or annual period as well as the information of the change of firm value in accounting measurement to its investors. Followed closely by the Wall Street, earnings reports are released four times a year for publicly-traded companies in the U.S. as it is required by law to report their financial results on a quarterly basis. To compare the earnings of different companies, investors and analysts often use the ratio earnings per share (EPS), which is the most important indicator of a company's financial health.

Before the actual earning reports come out, stock analysts issue the earnings estimates – what they think earnings will come in at. These forecasts are then compiled by research firms into the "consensus or mean earnings estimate". When a company beats this estimate it is called an earnings surprise, and the stock prices usually move higher. If a company releases earnings below these estimates, it is said to disappoint, and the prices typically move lower.

Totally earnings surprise includes pre-announcement surprise (a period between analysts' consensus forecast before the pre-announcement), the management earnings pre-announcement, and the earnings announcement surprise (a period between management earnings pre-announcement and actual earnings announcement). The results of recent studies indicate that earnings pre-announcements do influence reactions to the earnings news.

Numerous empirical studies have been conducted on various aspect of the earnings announcement. Soffer et al documents that pre-announcing firms with negative earnings announcement surprises have lower abnormal returns than do firms with positive announcement surprises. For most pre-announcements associated with negative total earnings news, managers release essentially all of the negative news with the pre-announcement, therefore avoiding the potential magnified reaction to the bad news that could result from two sequential negative surprises. Alternatively, most managers disclosing favorable news release only about half of the news in a pre-announcement which potentially benefiting from the magnified favorable reaction to two sequential positive surprises. Managers may be most interested in managing the expectations of current period earnings prior to formally announcing earnings as they are responsible for designing earnings communication strategies ("Soffer, Thiagarajan, and Walther, 2000").

Beaver examines the extent to which common stock investors perceive earnings to possess informational value. The study investigates the reaction of investors against the annual earnings releases as reflected in the volume and price movements of common stocks. Beaver hypothesizes that if earnings reports convey information in the sense of leading to changes in the equilibrium value of the current market price, the magnitude of the price change should be larger in the week of the announcement than during the non-report period and reports evidence of it ("Beaver, 1968").

The path breaking event study conducted by Fama et al, henceforth FFJR, innovated the methodology used in event studies since then. The FFJR study examines security returns around split dates to determine whether there is any unusual behavior ("Fama, Fisher, Jensen, and Roll, 1969").

In two papers, Brown and Warner examine the behavior of the stock returns around the announcements using monthly and daily return data respectively. In these extensive studies, they examine different abnormal return generating methods and conduct various sensitivity analyses ("Brown and Warner, 1980, 1985").

Several studies also focus on certain firm-specific characteristics for a better explanation of stock returns around the earnings announcements. Atiase focuses on firm size (capitalization) as one such characteristic. He argues that the amount of "unexoected" information conveyed to the market by actual earnings reports should be inversely related to firm capitalization ("Atiase, 1985"). Grant suggests that the market in which a firm's equity securities are traded leads the behavior of the average security price reaction to the earnings announcements ("Grant, 1990").

This paper examines if security prices change in response to earnings announcements. Good news announcement is when the company has positive earnings surprise, and bad news announcement is when the company has negative earnings surprise. This paper also provides the evidence that stock prices respond to the good earnings announcements positively and the bad earnings announcements negatively, and further analyzes the effects of the earnings announcements.

HYPOTHESIS

The earnings announcements in a firm will represent new information on the values of the firm and the future performance to investors. The stock price will respond to good earnings news and generate positive abnormal returns (PAR) and bad earnings news with negative abnormal return. We believe in the Market Efficiency Hypothesis, which means once the earnings announcements become public and the stock prices will react to the nature of information and in consequence the cumulative abnormal rate of return (CARR) should be positive for those firms with good earnings announcement news and negative for those firms with bad earnings announcement news.

THE DATA AND SAMPLE

In examining the samples of firms listed on the NYSE and obtain the data from Yahoo! Finance, The Wall Street Journal Online, and the Thomson ONE. 10 New Stock Exchange listed companies are selected randomly from different industries. There are samples of 38 earnings announcements from the second quarter 2005, first quarter 2005, fourth quarter 2004, and third quarter 2004. In 38 earnings announcements, there are 18 good news and 20 bad news. The good news is defined if the actual earnings are higher than the estimated earnings from the Wall Street Journal and vice versa for the bad news. Earnings announcements with no earnings surprises are omitted. Here are the ten companies.

1. CALPINE CP (CPN) - Electrical Utilities
2. DELPHI CORPORATIO (DPH) – Auto Part
3. GEN ELECTRIC CO (GE) – Multi-Ind Cap Good
4. GEN MOTORS (GM) – Automobile
5. LUCENT TECH INC (LU) – Office / Comm Equip
6. MARTHA STEWART LI (MSO) – Publishing
7. REVLON INC (REV) – Cosmetics
8. EXXON MOBIL CP (XOM) – Oil
9. COCA-COLA (KO) – Beverage
10. PFIZER INC (PFE) – Drugs

The dates where earnings announcements are released are defined as the event day (t = 0). For each event in the sample, a maximum of 30 daily rate of return are observed. The event window is defined as t = -15 ,…, +15 and non-event or estimation period as t = -30,…, -16 through +16,…,+30. Both stock prices and Standard and Poor's 500 index data are collected for event day, event window and non-event period.

METHOLOGY

The event-study methodology is used in this study to examine the reaction of investors to good and bad earnings announcements. The event-study methodology involves the following steps: (1) Define event dates where earnings announcements are released as t = 0, event window as t = -15 ,…, +15 and non-event or estimation period as t = -30,…, -16 through +16,…,+30. (2) Calculate the daily rate of return of stock price and S & P 500 Index for each event. (3) Estimate the normal return from estimation period. (4) Use market model to calculate the Abnormal

Return (Aggregate Return) by subtract the normal return from market return. (5) Calculate Average Aggregate Return (AAR) and Cumulative average abnormal returns (CAAR) from day -30 through day +30. (6) Testing whether the abnormal return is statistically significant or not.

The market model is used to estimate abnormal returns for each event. The market model assumes a linear relationship between the return of any security to the return of the market portfolio:

$$R_{it} = \alpha_i + \beta_i R_{mt} + e_{it}$$
$$with \quad E(e_{it}) = 0 \qquad and \quad Var(e_{it}) = \sigma_{e_i}^2$$

where t is the time index, $i = 1,2,\ldots,N$ stands for security, R_{it} and R_{mt} are the rate of returns on security i and the Standard and Poor's 500 index respectively during period t, and e_{it} is the error term for security i.

The prediction error (the difference between the actual return and the predicted normal return), referred to as the abnormal return (AR), is then calculated as:

$$AR_{it} = R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{mt}$$

α_i and β_i are the ordinary least-squares estimates for firm I's market model parameters. Ordinary least-squares regression is performed to estimate the coefficients of the market model separately for each event using the non-event return data (t = -30,…, -16 though +16,…,+30).

The average abnormal returns (AAR_t) are calculated by the following equation.

$$AAR_t = \frac{1}{N}\sum_{i=1}^{N} AR_{it}$$

The cumulative average abnormal return **(CAAR)** for the securities is equal to the sum of the average abnormal returns.

The test statistic described by Campbell et al is employed to test the significance of hypothesis. Under the null hypothesis, the abnormal returns are zero The test statistic on the cumulative average abnormal returns is as:

$$J_1 = \frac{CAAR(\tau_1,\tau_2)}{\bar{\sigma}^2(\tau_1,\tau_2)} \approx N(0,1) \text{ where } \bar{\sigma}^2(\tau_1,\tau_2) \text{ is the variance of } CAAR$$

If J_1 is significantly greater than zero, then we reject the null hypothesis that the event has no affect on securities returns and accept the alternative hypothesis that security returns are affected by the event ("Campbell, Lo, and MacKinlay, 1996").

RESULTS

In this study, stock prices do respond the earnings announcement news. Figure 1 presents the average abnormal returns and cumulative returns of earnings announcements on good news, and Figure 2 presents the average abnormal returns and cumulative returns of the earnings announcements on bad news. On the event day (t = 0), we found positive average abnormal returns (0.744%) for the firms with good earnings announcement and negative average abnormal returns (-1.951) for the firms with negative earnings announcements. The announcement effect is also evident on day one with average abnormal return of 0.0696% and -0.530 for good earnings announcement and bad earnings announcement respectively. From the Figure 1 and Figure 2, we can see clearly that the cumulative average abnormal returns (CAAR) shows that the markets gradually learn about the announcement. For the Figure 1 (good news), CAAR does not increase much before earnings announcement day, but it increases substantially after earnings announcement day, and increases slowly after t = 15. For the Figure 2, CAAR drops significantly after earnings announcement day. However, investors continue to believe in the firm and the market, and the CAAR increases after t = 10. The evidences of both good news and bad news on event day (t =0) are significant at 5% significant level. In Odabasi's paper, it indicates that the average abnormal return on the announcement day is significantly greater than zero (AAR = 0.31%) for the good news sample while it is significantly less than zero (AAR = -2.12%) for the bad news sample ("Odabasi, 1998"). In Kashefi et al's paper, it analyzes the stock prices' reactions with layoff announcements. The proactive layoff announcement indicates that the firm which has layoff announcement as a strategy or restructuring plan will deliver the investor the good news of higher growth in the future, and the stock price will go up ("Kashefi, Javad, Mckee, and Gilbert, 2002"). The average abnormal return for the proactive information is positive and it is negative for the reactive information. Consequently, this study's statistical results are consistent with previous studies of earnings announcements and show a high magnitude of cumulative average abnormal returns for the good and bad earnings announcements.

CONCLUSIONS

This study investigates security returns reaction to the earnings announcements. The event study is conducted on a portfolio of 10 stocks which made of 38 earnings announcements from third quarter earnings announcement of 2004 to second quarter earnings announcements of 2005. The good news sample includes 18 events while there are 20 events in the bad news sample. The result shows that the earnings drive stock prices. The average abnormal return, on the announcement day, is significantly greater than zero for the good news sample while it is significantly less than zero for the bad news sample.

Figure 1

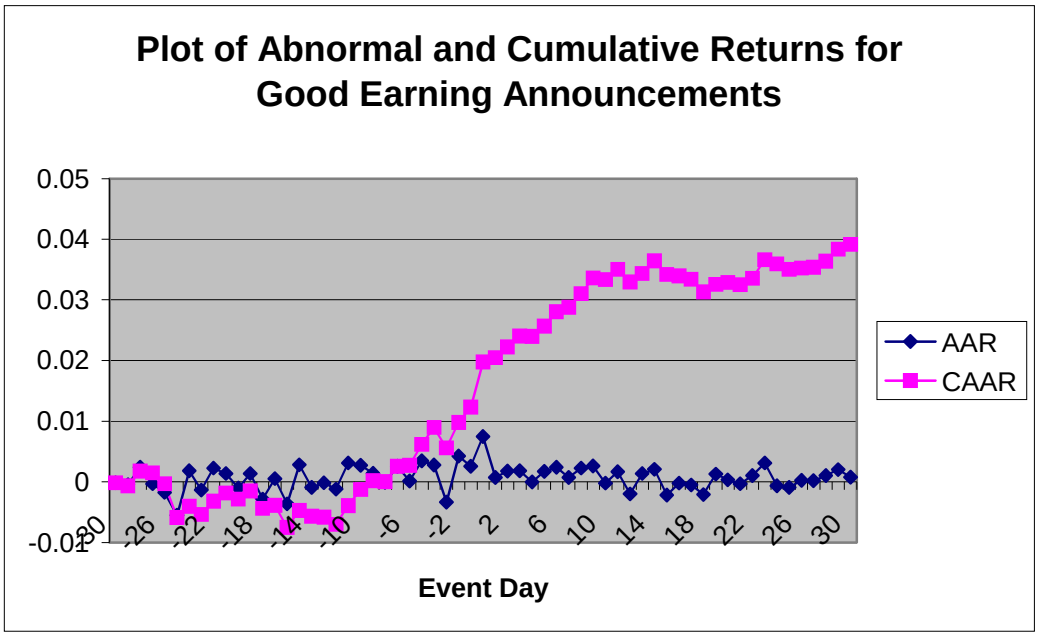
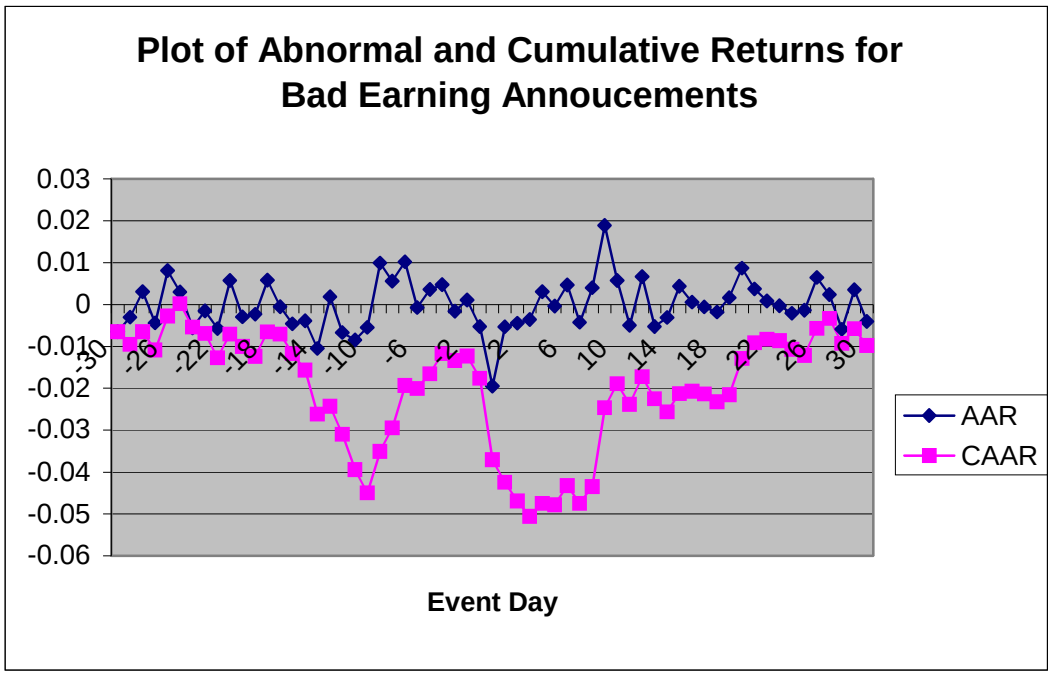


Figure 2



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THE EFFECT OF PRODUCT ANNOUNCEMENTS ON STOCK PRICES

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ABSTRACT

Newest innovations, latest product design, and technological advances, are key elements to gain market shares in its industry. Analysts and investors feel that product announcements signal to investors that the firm's management has embarked on plans to boost the company's stocks.

This paper examines stock price reactions to selected product announcements. A sample of ten US companies from various industries is analyzed. Our findings support the hypothesis that product announcements convey information useful for the valuation of firms. We find positive abnormal returns for the firms with proactive announcements and negative abnormal returns for the firms with reactive announcements.

KEYWORDS

Product Announcements and stock prices

INTRODUCTION

Product speculation and announcements are key factors for companies to create publicity and excitement for their companies. Apple's iPod nano, for example, shortly after being announced in September 2005, measuring merely at 27 inches thin and 1.5 ounces, with battery life up to 14 hours and 4GB of storage, bright colour display, Apple Click Wheel, and Dock connector that fits an entire ecosystem of iPod accessories, has become the most popular holiday gift gadget of the year resulting in a positive impact on Apple's stock price, which climbed 3.3 percent to close at $69.34 and helped its index hit a 4-1/2-year closing high. On the other hand, Creative's WebCam Live Motion, which was also announced in September 2005, has received only mediocre reviews from the consumers and analyst because of its buggy software, difficulty in initial setup, and high price. Creative's stock price dropped 3.34% five days after the announcement and continued to drop another 1.73% to 5.07% ten days post the announcement.

Some empirical studies have been conducted on various aspects of product announcements. For example, the study analyzes how strategic competition, in this case new product announcements, affect firm values ("Sheng-syan Chen, Kim Wai Ho, Kue Hwa Ik and Cheng-few Lee, 2002"). The other study analyses the impact of announcements of new product introductions on the stock price of pioneering firms and their rivals to determine whether first-movers gain long-term competitive advantages ("Zaher Zantout and Radha Chaganti, 1996").

This paper investigates the impact of product announcements classified as reactive (negative) or as proactive (positive) which occurred over the past five years. Proactive announcements are defined as products that are part of strategy or a marketing plan that anticipates the direction of

the competitive environment. Reactive announcements are products that are a direct response to a financial distress, reaction to competitor's announcement, or lost opportunities.

In the context of our analysis, a product announcement is considered proactive (positive) when it is associated with an increase in stock price. The resultant higher stock price reflects popular product and positive demand. The product announcements are considered reactive (negative) if the company has a decrease in stock price. The lower stock price reflects negative reviews or low demand.

HYPHOTHESIS

A company's product announcement is information signalling to investors about the future prospects of the company's earnings and cashflow and should have an impact on stock prices. The company's product announcements represent new information to investors that affect their estimates of future stock prices. If true, the abnormal rate of return should be positive for products that receive positive reviews and high anticipation and negative return for companies' products that receive negative feedback and do not bring eagerness.

DATA AND METHODOLOGY

Data Sources and Sample Construction

A sample of product announcements for the US companies has been obtained from money central NBC. Product announcements with close dates (i.e. Nokia product announcement in December 1,2005 was merged with the product announcement in September 29,2005 for the launches of Nokia 6234, 6233, 6282 for the month of December and Nokia 9300i in September) have been combined, and the more appropriate (popular) samples have been selected instead. The resulting sample consists of 40 product announcements for companies listed on NASDAQ and New York Stock Exchange. Since companies traded on exchange as well as over-the-counter are included, the sample is not biased towards small or large companies.

The model is separated into two groups, consisting of 22 product launches with proactive announcements and 18 product releases with reactive announcements. Historical stock prices were obtained from Yahoo Finance's Historical Data.

Event Study Methodology

Event methodology used is to record the companies' stock prices five days prior the product announcements and compare the prices to the stock prices five days post the product announcements. Furthermore, stock prices ten days of the product announcements also being compared to see if the trend is consistent with the hypothesis.

Formula used to measure the growth for proactive announcements:

$$\text{Growth 5 days} = (P_{+5 \text{ days}} - P_{-5 \text{ days}}) : P_{-5 \text{ days}}$$

$$\text{Growth 10 days} = (P_{+10 \text{ days}} - P_{-5 \text{ days}}) : P_{-5 \text{ days}}$$

Formula used to measure the growth for reactive announcements:

Growth 5 days = ($P_{-5\ days}$ - $P_{+5\ days}$) : $P_{-5\ days}$

Growth 10 days = ($P_{+10\ days}$ – $P_{-5\ days}$) : $P_{-5\ days}$

RESULTS

Table 1 presents the percentage changes which occurred five days before and five days post product announcements and the average abnormal returns for each of the two product announcements categories. Table 2 presents the percentage changes during five days before and ten days post announcements and the average abnormal returns for each of the two product announcements. Charts of the average returns are shown at the bottom of the tables.

The results are largely consistent with the existing literature on the information content of product announcements. The evidence strongly supports the hypothesis that product announcements do indeed convey information useful for the valuation of firms. Focusing five days post the announcement day, the total average abnormal return for the proactive information is 2.72%. The total average abnormal return for reactive information is -1.52%. The announcement effect is consistent with the ten days post announcement day, the total average abnormal return for the proactive information is 3.56% and the total average abnormal return for the reactive information is -2.39%.

SUMMARY

Over the sample period, U.S. Corporations announced many product announcements despite risk of receiving negative feedbacks from analysts and consumers or low level of enthusiasm. To investigate the effect of the product announcements on firm value, we have defined two types of product announcements. Product announcements that are part of strategy or a marketing plan are considered to be proactive announcements. Product announcements that do not meet consumers' reviews and expectations are consequently considered to be reactive announcements. We find positive abnormal returns for the products with proactive announcements and negative abnormal returns for the products with reactive announcements. Further studies should be conducted to measure the correlation between product announcements and sales or earnings. Such studies will further enhance the relationship between product announcements and firm values.

LEGENDS		**Proactive announcement**			**Reactive announcement**	
Stock	**Nike**			**Creative**		
	5 Days Before	**5 Days After**	**10 Days After**	**5 Days Before**	**5 Days After**	**10 Days After**
P1 Price	$88.95	$85.89	$86.63	$8.40	$8.82	$8.98
Date | Product	1/20/05	**Nike Rockstar Workout**		12/8/05	**Zen Vision M**	
P2 Price	$74.83	$75.11	$76.58	$7.42	$8.08	$7.92
Date | Product	3/11/04	**Air Jordan XIX**		11/17/05	**Zen Neeon Dual OLED**	
P3 Price	$55.25	$55.42	$57.48	$7.60	$7.38	$7.45
Date | Product	8/21/03	**Women's Golf Equipment Line**		10/19/05	**I Trigue L3800**	
P4 Price	$45.10	$44.47	$45.78	$8.08	$7.81	$7.67

LEGENDS Proactive announcement Reactive announcement

Stock	Dell			Nokia		
	5 Days Before	5 Days After	10 Days After	5 Days Before	5 Days After	10 Days After
P1 Price	$29.40	$30.04	$30.22	$17.50	$17.67	$18.22
Date | Product	11/16/05	Photo All in One Printer & LCD		12/1/05	Nokia 6234, 6233, 6282 & 9300i	
P2 Price	$32.05	$31.88	$29.60	$17.19	$17.31	$17.24
Date | Product	10/26/05	XPS M140 & E310		11/7/05	Nokia 770	
P3 Price	$34.20	$32.53	$33.15	$16.09	$16.82	$17.04
Date | Product	10/6/05	Laser Printer 1710n		10/26/05	Nokia 2855 & 6165	
P4 Price	$34.65	$33.82	$31.88	$16.81	$16.17	$16.29
Date | Product	9/20/05	Axim X51 & Dell DJ		10/18/05	Nokia E60, E61 & E70	

Stock	Canon			Hasbro		
	5 Days Before	5 Days After	10 Days After	5 Days Before	5 Days After	10 Days After
P1 Price	$56.30	$58.00	$59.26	$20.10	$20.40	$20.57
Date | Product	12/1/05	imageRunner 5070		11/23/05	X Box Games	
P2 Price	$51.82	$52.38	$52.60	$21.45	$21.27	$20.04
Date | Product	9/14/05	XL H1 HD Camcorder &		9/14/05	Tween Electronics	
P3 Price	$51.82	$52.38	$51.25	$20.71	$20.22	$20.29
Date | Product	8/14/05	LASER CLASS 310		3/30/05	Star Wars Toys & Games	
P4 Price	$51.21	$51.28	$52.10	$20.40	$20.24	$20.29
Date | Product	8/31/05	VB-C50FSi Fixed Network		2/10/05	ION Educational Gaming System	

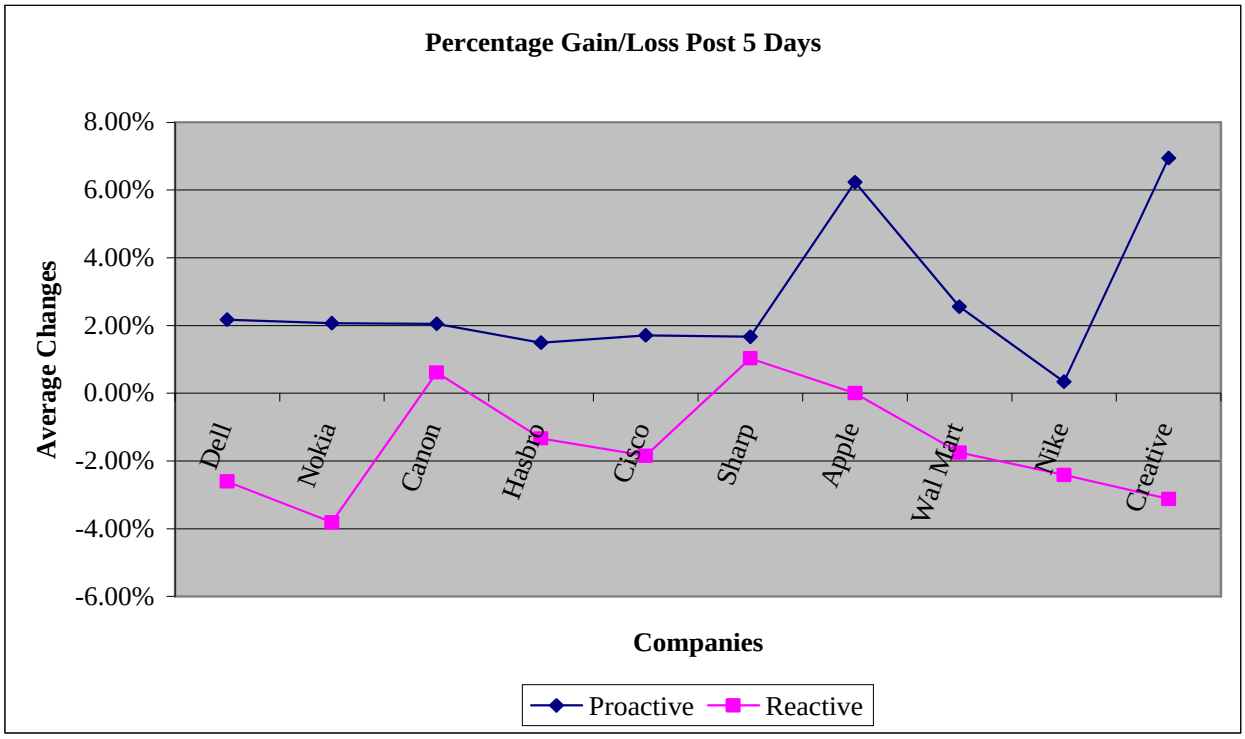
Stock	Cisco			Sharp		
	5 Days Before	5 Days After	10 Days After	5 Days Before	5 Days After	10 Days After
P1 Price	$17.44	$17.50	$17.64	$15.45	$15.60	$15.55
Date | Product	11/28/05	MIMO Based Products		5/24/05	LQ043T3DX02 TFT LCD	
P2 Price	$16.93	$17.45	$17.87	$15.70	$15.90	$15.75
Date | Product	10/25/05	Cisco MDS 9020		2/25/05	XG PH50X Projector	
P3 Price	$17.63	$17.17	$17.16	$14.45	$14.85	$15.20
Date | Product	10/12/05	Internet Telephony Kit CIT 200		11/8/04	IT 23M1U LCD TV	
P4 Price	$18.37	$18.17	$18.05	$14.55	$14.70	$14.10
Date | Product	9/13/05	Linksys WRT54GX2		7/29/04	AQUOS LCD HDTV	

Stock	Apple			Wal Mart		
	5 Days Before	5 Days After	10 Days After	5 Days Before	5 Days After	10 Days After
P1 Price	$54.00	$56.79	$57.59	$43.82	$44.94	$45.24
Date | Product	10/19/05	Aperture		10/7/05	Metro 7 collection	
P2 Price	$51.30	$53.44	$55.66	$51.61	$52.42	$51.30
Date | Product	10/12/05	Video iPod & iTunes 6		3/3/05	Walmart Discover	
P3 Price	$52.11	$54.44	$52.78	$55.32	$52.51	$52.95
Date | Product	9/26/05	FileMaker Server 8		12/3/04	Business All in One card for	
P4 Price	$46.26	$51.40	$52.64	$56.26	$57.70	$55.25

LEGENDS	
	Proactive announcement
	Reactive announcement
	Total Average Proactive Abnormal Return
	Total Average Reactive Abnormal Return

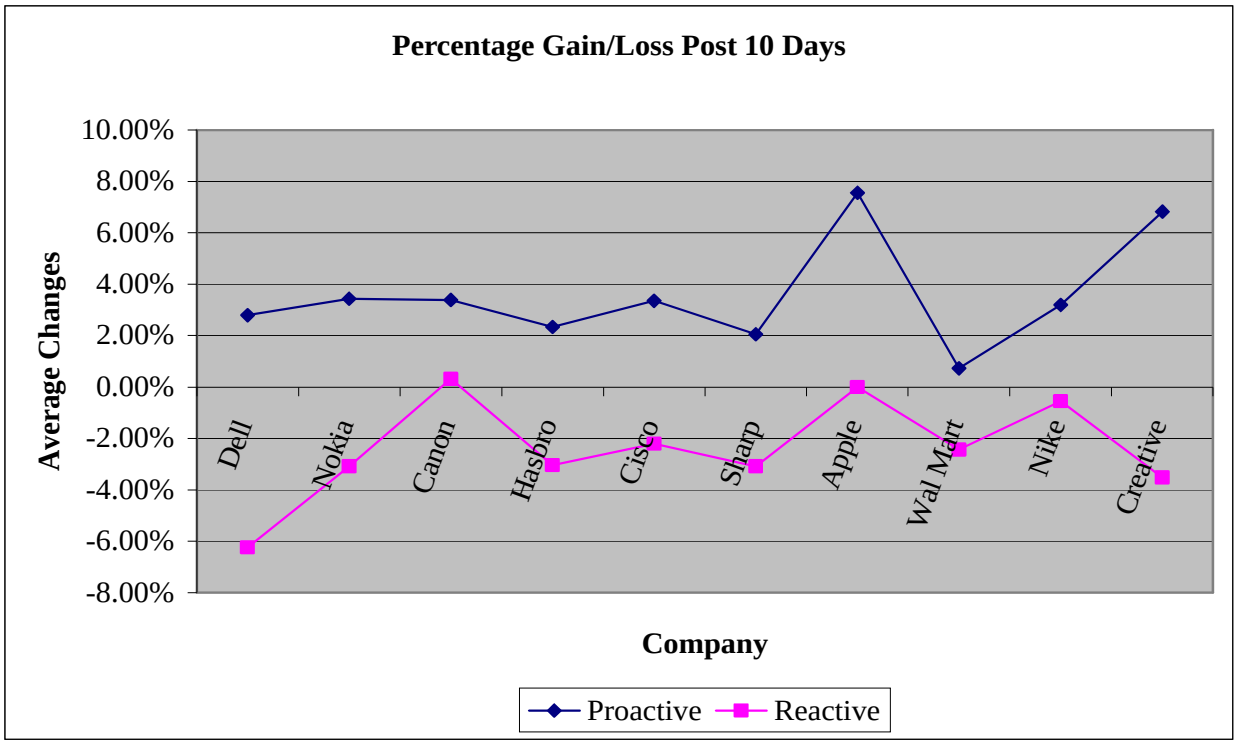
Table 1 **Percentage Change (5 Days before - 5 Days after the Announcement)**

	P1 Price	*P2 Price*	*P3 Price*	*P4 Price*	*Avg (Proactive)*	*Avg (Reactive)*
Dell	2.18%	-0.53%	-4.88%	-2.40%	2.18%	-2.60%
Nokia	0.97%	0.70%	4.54%	-3.81%	2.07%	-3.81%
Canon	3.02%	1.08%	1.08%	0.14%	2.05%	0.61%
Hasbro	1.49%	-0.84%	-2.37%	-0.78%	1.49%	-1.33%
Cisco	0.34%	3.07%	-2.61%	-1.09%	1.71%	-1.85%
Sharp	0.97%	1.27%	2.77%	1.03%	1.67%	1.03%
Apple	5.17%	4.17%	4.47%	11.11%	6.23%	0.00%
Wal Mart	2.56%	1.57%	-5.08%	2.56%	2.56%	-1.76%
Nike	-3.44%	0.37%	0.31%	-1.40%	0.34%	-2.42%
Creative	5.00%	8.89%	-2.89%	-3.34%	6.95%	-3.12%
TOTAL					**2.72%**	-1.52%



LEGENDS	
	Proactive announcement
	Reactive announcement
	Total Average Proactive Abnormal Return
	Total Average Reactive Abnormal Return

Table 2	Percentage Change (5 Days before - 10 Days after the Announcement)					
	P1 Price	*P2 Price*	*P3 Price*	*P4 Price*	*Avg (Proactive)*	*Avg (Reactive)*
Dell	2.79%	-7.64%	-3.07%	-7.99%	2.79%	-6.24%
Nokia	4.11%	0.29%	5.90%	-3.09%	3.44%	-3.09%
Canon	5.26%	1.51%	-1.10%	1.74%	3.38%	0.32%
Hasbro	2.34%	-6.57%	-2.03%	-0.54%	2.34%	-3.05%
Cisco	1.15%	5.55%	-2.67%	-1.74%	3.35%	-2.20%
Sharp	0.65%	0.32%	5.19%	-3.09%	2.05%	-3.09%
Apple	6.65%	8.50%	1.29%	13.79%	7.56%	0.00%
Wal Mart	3.24%	-0.60%	-4.28%	-1.80%	0.72%	-2.44%
Nike	-2.61%	2.34%	4.04%	1.51%	3.19%	-0.55%
Creative	6.90%	6.74%	-1.97%	-5.07%	6.82%	-3.52%
TOTAL					**3.56%**	-2.39%



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MIGRATION AND FOREIGN REMITTANCES: A COMPARATIVE STUDY OF TONGA AND GUATEMALA

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ABSTRACT

An important feature of both the TONGAN and GUATEMALAN economies is the presence of international migration and the remittance flows arising from such migration. There has been discussion in the literature that these remittances play an important role in economic stabilization due to their support of household expenditures. It is still not clear what the long term economic effect of these inflows is on economic development.

The purpose of this paper is to analyze the pattern of migration and to determine how these remittances affect economic growth. In addition, it will provide a comparison of the differences of these patterns and effects on two countries: TONGA AND GUATEMALA... At one point some of the weaknesses that Latin America was exposed to were inflation, weak currencies, and political instability. (Bartham, 2006) These were all endogenous factors. Although, these factors are still present, global liquidity and fiscal consolidation has dampened some of these effects. However, global risk plays a more important role than ever.

INTRODUCTION

TONGA AND GUATEMALA have experienced tremendous changes over the years in terms of its migration patterns. As a result of these changes large remittance flows have prominent roles in both the TONGAN AND GUATEMALAN economies and result in a short term stabilizing effect on these economies. With regards to this, an important issue that needs to be addressed is: What are the long term effects on the economies of these countries? The analysis will include financial and sociological perspectives on the long term implications of this dynamic. The authors will compare the impact of financial remittances from abroad on the countries of TONGA AND GUATEMALA. TONGA has been selected as a country to analyze since it has the largest percentage of its economy depending on the inflow of monies from its emigrants.
GUATEMALA has been chosen as a basis for comparison as an example of a country with a large, but far lower, percentage of remittances. For a comprehensive review of the literature on remittances, see Rapoport and Docquier (2005).

EMPIRICAL FINDINGS

At the time of this writing, the empirical results have not yet been completed. It is expected that the analysis will be complete at the time of the conference.

Remittances are generally defined as the sum of three items in the IMF s Balance of Payment Statistics Yearbook (BOPSY) (all the details are in Appendix 1): workers remittances, compensation of employees, and migrant transfers. This is, for instance, the standard definition in the World Development Indicators and the Global Development
Finance databases of the World Bank. In the empirical analysis, we should find a larger impact of
Remittances in the sub sample of countries where the financial system is less developed.

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RISK, VOLATILITY, AND UNCERTAINTY IN LATIN AMERICAN MARKETS

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ABSTRACT

At one point some of the weaknesses that Latin America was exposed to were inflation, weak currencies, and political instability. (Bartham,2006) These were all endogenous factors. Although, these factors are still present, global liquidity and fiscal consolidation has dampened some of these effects. However, global risk plays a more important role than ever.

The purpose of this paper is to explore and analyze those global risk factors that have and will continue to influence Latin American financial markets.

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Cultural Factors in Global Retail Banking: The Case of Citibank

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Cultural Factors in Global Retail Banking: The Case of Citibank

Abstract

This paper examines the impact of culture on the presentation of country-specific online bank sites at Citibank. Despite a strong attempt at consistency, Citibank's online banking sites in different countries appear to be adapted to local cultural attributes. The most important factors explained by cultural differences on the country-specific web sites are found to be the portrayal of human images, particularly people as customers, people in family groupings, and the gender of the individuals portrayed.

Introduction

The emergence of online banking as an important channel of distribution for conventional banking products and services has created challenges for banks attempting to develop an international presence (Crede, 1998). Many U.S. banks are in the process of expanding internationally. It is clear that ". . . the Internet opens a low-cost, high growth channel to the international investor. . ." (Otalvaro, et.al., 1998, p. 251.) An Internet site for banks creates a competitive milieu in which they not only compete with other banks, but a broad array of non-banking providers of financial services (Singh and Kundu, 2002.) These competitive forces drive banks to a posture where they must correctly assess consumer needs, desires, tastes and preferences in order to make their web sites competitive (Bruno-Britz, 2006). "On line retail banking has instigated a desperate positioning battle among competing companies from all different sectors of the financial services industry." (Kalakota, et.al., 1998, p.19.) In differentiating its sites across national boundaries, Citibank is assumed to be affected by, and has responded to, these pressures.

There are a number of reasons that argue for the adaptation of bank web sites to local economic conditions, customs, tastes, preferences and values. One argument is that web sites have an inherent moral component (Cooper, 2006.) Therefore, to be creditable, the site moral values must be reflective of the target population. The second argument arises from the fact that the ultimate success of a web site is whether or not existing customers use it or potential customers are attracted to it (Rai and Jain, 2006). To be successful online banking sites must create value for users. The fact that business practices in general are heavily impacted by local culture and market conditions is well established. There is every reason to expect that this would also be true for online banking web sites.

Citibank

Citigroup is a $1.5 trillion (in assets) holding company whose principle retail banking activities are conducted through Citibank. The U.S. Citibank home web page (http://www.Citibank.com/us/d.htm) provides direct links to 68 country-specific web

sites, from Algeria to Zambia. Citigroup is committed to aggressive growth: "We estimate that approximately 750 million potential new consumer customers, largely outside the United States, will emerge over the next five years—an unprecedented opportunity . . . for Citigroup." (Annual Report, 2005, p.4).

Cultural Dimensions

This study uses a set of four cultural dimensions developed by Geert Hofstede.

- The, Power Distance Index (PDI), which measures the extent to which individuals in a society accept as the normal state of affairs that power is distributed unequally,

- The Individualism Index (IND) which measures the strength to which the needs of the individual supercede the needs of group.

- The Masculinity Index (MAS) which measures the tendency of society to be more competitive and assertive and less caring, nurturing, and modest.

- The Uncertainty Avoidance Index (UAI) which measures society's inability to tolerate uncertainty and ambiguity.

Culture and Online Banking

Forty five of the sixty eight Citibank country-specific web sites for which the Hofstede cultural dimensions were available were surveyed. Each site was examined for 19 properties that were thought *a priori* to be related to UAI, PDI, MAS, or IND. Dummy variables were used to indicate the presence (1) or absence (0) of these properties. The various properties examined included people in a variety of formats (e.g., authority figures, professionals, customers), the age and gender of the people, the setting (technical, professional, or scenic) of the web site, games of chance, the color scheme, the language used, and the number of products offered directly.

Analysis of Cultural Dimensions

Each of Hofstede's cultural dimensions was found to have an impact on the attributes of Citibank's different web sites. The most important factors explained by cultural differences on the country-specific web sites were found to be the portrayal of human images, particularly people as customers, people in family groupings, and the gender of the individuals portrayed. The analysis was conducted by a single-stage regression of the measured web page features against the specific cultural dimensions used.

Table 1

Regressions of Website Characteristics on Cultural Dimensions

Cultural Dimensions	Intercept	Customers	Families	People	Males	Statistics
Uncertainty Avoidance Index (UAI)	11.44	–6.58	–6.1	–19.48	– 2.95	$R^2 = 0.47$, F = 1.06
Masculinity Index (MAS)	44.67	3.05	–49.38	–33.38	2.09	$R^2 = 0.52$, F = 1.29
Individualism Index (IDI)	17.47	-24.27	-35.48	53.47	– 1.34	$R^2 = 0.375$, F = 0.72
Power Distance Index (PDI)	10.94	17.73	26.68	–19.9	7.66	$R^2 = .42$, F = 0.895

Uncertainty Avoidance

This regression in Table 1 suggests that human beings depicted in any form on the web site are negatively associated with higher levels of uncertainty avoidance value. The implication of this finding is that Citibank consciously uses these human images on its website to allay the desire to avoid uncertainty in the culture. The higher the desire to avoid uncertainty in the culture, the more likely Citibank is to present people on its website.

Masculinity

The display of customers, families, people, and males on Citibank country-specific we sites was also found to be sensitive the degree of Uncertainty Avoidance present in that country (see Table 1.)

The indication of this regression is that the more masculine the culture the more likely this is to effect the manner in which people are portrayed on the website. In particular, a strong masculinity value is positively but weakly associated with both customers and male figures. This may reflect an opportunity of the masculine person to compete. A much stronger negative effect is found by the presence of family groupings and people in general. A more masculine orientation may consider "family" issues out of place in a business context. Indeed, a more masculine culture may prefer its banking activities take place is a strictly mechanical environment.

Individualism

Individualism was also seen to impact the display of customers, families, people, and males on Citibank country-specific we sites (Table 1.) Individuals in societies with a strong individualistic orientation appear to display a preference for bank web sites with individuals present. However, the individuals should not be customers or in family settings. The more individualistic the society, the more attracted they will be to sites depicting professionals at work in a banking context. Where there is a collectivist

orientation in societal values, the presence of family groupings and customers may prove more attractive.

Power Distance

The acceptance and expectation of Power Distance between individuals was also seen to impact the display of customers, families, people, and males on Citibank country-specific we sites (Table 1.)

In cultures that expect and accept a gulf between ordinary citizens and the elite, the display of customers, families and males on the web site appears to be used to signal potential web site users that it is OK for them to engage in this activity. That they should feel comfortable in an online banking environment. Conversely, in a society with a high PDI Index, the absence of individuals on a web site may serve to imply that ordinary customers are not welcome. An absence of individuals displayed on the web site may suggest that this activity is reserved for the elite members of society.

Conclusion

Cultural values are found to be taken into consideration by Citibank in determining the form, composition, and content of its web sites across international borders. Given that Citibank is a profit maximizing organization intent on using its web sites to capture a growing amount of banking business in the international arena, it appears to have found that it can create more effective web sites by taking into account cultural values with respect to individualism, power distance, masculinity, and uncertainty avoidance.

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CRITICAL SUCCESS FACTORS FOR U.S. EXPATRIATE ASSIGNMENTS AND INTERNATIONAL BUSINESS TRANSACTIONS IN ARGENTINA, BRAZIL, AND CHILE

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EXPANDED ABSTRACT

According to the 2004 Foreign Direct Investment Confidence Index, for the first time since 2000, a sizable majority of leading executives are more optimistic about the global economy and corporate investors expressed an increased willingness to make overseas investments. The U.S. is following this trend as well. As reported by the Organization for Economic Cooperation and Development (OECD, 2004), outflows of foreign direct investment (FDI) from the United States reached an all time high of $252 billion in 2004-up from $141 billion in 2003. This indicates that U.S. companies are very interested in acquiring corporate assets abroad.

The OECD (2004) also reported overall increased FDI inflows into Latin America, especially from the United States. Argentina, Brazil, and Chile seem to particularly attractive as investment sites. In 2004, the level of FDI inflows into Argentina was $4 billion, $18 billion into Brazil, and $8 billion into Chile. These numbers were all around twice the FDI inflows recorded in 2003. Furthermore, A.T. Kearney's 2005 Global Retail Development Index (GRDI) rated Chile as a good international investment opportunity for mass merchant and food retailers looking to expand overseas. Some of the reasons cited for US FDI interest in Latin America include lowered economic barriers, overall government stability, availability of cheap labor and natural resources, strategic location, and an increasingly free-spending population (WEF Competitiveness Report, 2006). The complete research paper will analyze the specific reasons for the attractiveness of Argentina, Brazil, and Chile for US FDI.

The increase in FDI outflows from the U.S. into Argentina, Brazil, and Chile will amplify the frequency of international business transactions and the number of expatriate workers. Unfortunately, many of these international business dealings and expatriate assignments will not be entirely successful. Many expatriate assignments fail or end early due primarily to expatriate's or spouse's inability to adjust to the new cultural environment (Tung, 1982; Solomon, 1994), especially when the host country has significantly different political, economic, and cultural environments from that of the home country. Therefore, successful expatriate placement depends on the expatriate worker's ability to adjust to the new cultural values and norms of his/her host country (Hogan & Goodson, 1990; Flynn, 1995). Knowledge of the host country, including its culture, is crucial. Since culture is such an important factor, it is curious that this is not listed in the literature as one of the items that make a country attractive for FDI. The final paper will explore this issue in detail and look at cultural differences between the home and host countries along with other relevant factors affecting international business transactions..

As we explore cultural variables in Argentina, Brazil, and Chile, more than one of the existing cultural frameworks will be utilized. There are many studies and frameworks that illustrate cultural differences of nations (Adler, 1997; Hall, 1981; Hofstede, 1980, 1997, 2001; Trompenaars & Hampden- Turner, 1998). As mentioned earlier, culture is an important factor in expatriate success and international business dealings as it affects individuals in the way they think, feel, behave, and perceive the world. In addition, culture shapes an individual's system of values and this in turn shapes how one approaches the issues of decision-making and problem solving, leadership and power, and the management and motivation of workers in the workplace. Cross-border business transactions involve interaction with different societal value systems. The finished paper will also investigate the related issues of time (monochronic vs. polychronic) and communication (low context vs. high context) for each country and compare these variables to those in the US.

We will look at the cultural values in Argentina, Brazil, and Chile and compare them to those in the US in order to determine cultural distance or intercultural disparity index (IDI). The IDI is based on Hofstede's cultural dimensions and is used to measure the relative distance of two given cultures and therefore the existence of relevant cultural differences. It is the extent to which the culture of the originating region (United States) differs from that of the host region (Argentina, Brazil, Chile). We feel that the most critical success factor for US expatriate assignments and international transactions in Latin America is low IDI. High IDI translates into potential cultural clashes in the workplace since different cultural systems translates into different methods of communicating, different work habits and goals, different decision-making styles, and different motivational methods. As such, leadership behaviors have to be adjusted and adapted to the cultural value systems of the host countries. This further highlights the importance and need for cross-cultural training for those engaged in doing business in Argentina, Brazil, and Chile. The final paper will identify appropriate training modules as well which will be useful for practicing managers in the development of organizational strategies and overall training programs.

References available upon request.

A GENERALIZED APPROACH TO FUZZY MULTI-ATTRIBUTE DECISION MAKING

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ABSTRACT

We propose a generalized approach to the already existing crisp methods to solve the fuzzy multi-attribute decision making problem. Specifically we deal with four methods, namely Simple Additive Weighting, Linear Assignment, TOPSIS and ELECTRE, where fuzzy numbers are used to represent the ratings of the alternatives and relative weights of the attributes. Through the use of fuzzy mathematics we adapt the crisp algorithms to handle fuzzy data. This enables us to analyze fuzzy data without having to learn new algorithms. We illustrate the use of two methods due to Lee and Li & Dubois and Prade for comparison of fuzzy numbers through a numerical example.

KEYWORDS

Fuzzy; MADM; Simple Additive Weighting; Linear Assignment; TOPSIS; ELECTRE

INTRODUCTION

In this paper, we focus on multi-attribute decision making (MADM) problems through Linear Assignment, Simple Additive Weighting, and Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) and ELECTRE methods. In following the steps of methods recommended by us, we expect the user to follow the methodology in Hwang and Yoon [3] to deal with crisp data. We make use of methods developed by Lee and Li [4], and Dubois and Prade [2] for comparison. In order to obtain a comparable scale, we use the linear scale transformation over vector normalization for reducing computational complexity. For separation measures, we use the separation of convex fuzzy sets of Zadeh [7].

PROBLEM STATEMENT AND SOLUTION METHODOLOGY

In the fuzzy MADM problem, the ratings of alternatives (x_{ij}) and the relative weights of the attributes (w_j) are frequently described by linguistic variables which can be easily modeled by trapezoidal fuzzy numbers. Mathematically our problem can be described as follows:
Choose an alternative A_i from the decision matrix shown in Table 1, where any alternative A_i has a fuzzy rating of $\mathbf{x}_{ij}$ in attribute j, and any attribute X_j has a weight of $\mathbf{w}_j$ for i = 1, 2, . . . , m and j = 1, 2, . . . , n . Also $\mathbf{x}_{ij}$ and $\mathbf{w}_j$ are trapezoidal fuzzy numbers where,
$\mathbf{x}_{ij} = [\, \mathbf{x}_{ij1} , \mathbf{x}_{ij2} , \mathbf{x}_{ij3} , \mathbf{x}_{ij4} \,] \;\forall$ i and j ; $\mathbf{w}_j = [\, \mathbf{w}_{j1} , \mathbf{w}_{j2} , \mathbf{w}_{j3} , \mathbf{w}_{j4} \,] \;\forall$ j

SIMPLE ADDITIVE WEIGHTING METHOD

Step 1: Comparable Scale. Using the linear scale transformation, we get the comparable scale as follows:
$\mathbf{r}_{ij} = \mathbf{x}_{ij} / \mathbf{x}_j^{*}$, if j is a benefit criterion, and $\mathbf{r}_{ij} = \mathbf{x}_j^{min} / \mathbf{x}_{ij}$, if j is a cost criterion.

The determination of $\mathbf{x}_j^{*}$ or $\mathbf{x}_j^{min}$ involve comparison of fuzzy numbers for the same attribute j. We suggest the use of the Lee and Li [4] method, or the Dubois and Prade [2] method. In the Lee and Li [4] method if there is a tie in the generalized mean, we use the fuzzy number with a lower value of standard deviation as proposed by McCahon [5]. In case of a tie using the four indices as suggested

by Dubois and Prade [2], we recommend the use of any MADM method. The comparable numerical decision matrix can then be formulated as shown in Table 2. We let each $\mathbf{r}_{ij}$ remain as a division of two fuzzy numbers.

Step 2: Weighted Average Values. For any alternative A_i, the weighted average value, $\mathbf{WAV}_i$, is defined as:

$$\mathbf{WAV}_i = \sum_{j=1}^{n} \mathbf{r}_{ij} (.) \mathbf{w}_j, \text{ for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n$$

Step 3: Comparison of Weighted Average Values. From Step 2, we have non-trapezoidal fuzzy numbers due to fuzzy division and multiplication. The comparison can then be done using the Lee and Li [4], and Dubois and Prade [2] methods on the approximated trapezoidal fuzzy numbers. We select an alternative with the largest $\mathbf{WAV}_i$.

LINEAR ASSIGNMENT METHOD

Step 1: Attribute Preferences. This step requires a determination of the rank of an alternative in an attribute. For example in a benefit attribute, if the rating of an alternative is third highest, that alternative will have a rank of 3. In a general case, if an alternative I has a rank of 1 in the attribute X_1, and an alternative C has a rank of m in the attribute X_n, then the attribute preferences can be shown as in Table 3.These ranks can be determined using the two methods of comparison : (i) Lee and Li [4] and (ii) Dubois and Prade [2].

Step 2: Product-Attribute Matrix. This matrix is a (m x m) matrix, where any element π_{ij} essentially represents the sum of the weights of different attributes and an alternative i has a rank of j. Because of the nature of the problem, this matrix will consist of trapezoidal fuzzy numbers as shown in Table 4. For example, π_{11} is the sum of weights of attributes where the alternative A_1 has a rank of 1, π_{2m} is the sum of weights where the alternative A_2 has a rank of m, etc. If the alternatives are tied, one-half or one-third of the weights are used depending on whether two or three alternatives respectively are tied.

Step 3: The Fuzzy LP Formulation. Maximize $\sum_{i=1}^{m} \sum_{k=1}^{m} \pi_{ik} P_{ik}$

subject to

$$\sum_{i=1}^{m} P_{ik} = 1, \text{ for } i = 1, 2 \ldots, m$$

$$\sum_{k=1}^{m} P_{ik} = 1, \text{ for } k = 1, 2, \ldots, m \text{ and } P_{ik} \geq 0, \text{ for all i and k}$$

Step 4: Solve the Fuzzy LP Problem. The fuzzy LP set up in Step 3 is solved using the fuzzy linear programming methodology.

TOPSIS

Step 1: Normalized Decision Matrix. This is achieved using the steps discussed under Simple Additive Weighting Method. The crisp method uses vector normalization. We suggest avoiding the complicated use of the extension principle and also in not having to worry about whether a criterion is a benefit or cost criterion. We use the linear scale transformation as discussed in Hwang and Yoon [3]. We obtain the comparable scale matrix shown in Table 2.

Step 2: Weighted Normalized Decision Matrix. This fuzzy matrix is formulated as shown in Table 5, where any element, $\mathbf{v}_{ij} = \mathbf{w}_j (.) \mathbf{r}_{ij}$. Just as in the Simple Additive Weighting Method, we will approximate the fuzzy multiplication and division.

Step 3: Ideal and Negative Ideal Solutions. This is determined using the two methods of comparison. For each criterion j, an ideal solution is one where $\mathbf{v}_{ij}$ is maximum for i = 1, 2, . . ., m.

Similarly a negative ideal solution is one where $\mathbf{v}_{ij}$ is minimum for i = 1, 2, . . . , m. Using the Lee and Li [4] method for comparison of fuzzy numbers, we select the alternative with the largest generalized mean. Similarly using the Dubois and Prade [2] method, the alternative selected is determined using the order of the four indices. The ideal and negative ideal solutions are v_j^* and v_j^- respectively.

Step 4: Separation Measures. In order to calculate the separation measures, we make use of the city block distance presented in Hwang and Yoon [3] for crisp data. These indices associated with the positive ideal and negative ideal solutions for fuzzy data are defined as follows.

$$S_i^* = \sum_{j=1}^{n} | \mathbf{v}_{ij} - \mathbf{v}_j^* |, \; i = 1, 2, \ldots, m \text{ and } S_i^- = \sum_{j=1}^{n} | \mathbf{v}_{ij} - \mathbf{v}_j^- |, \; i = 1, 2, \ldots, m$$

Since the city block distance separation measure is the same as Zadeh's [7] measure for distance between two fuzzy sets, we use Zadeh's [7] formula.

Step 5: Relative Closeness to the Ideal Solution. This is defined considering the S_i^* and S_i^- indices defined in Step 4. $C_i = S_i^- / (S_i^- + S_i^*)$

Step 6: Preference Order. In this step, the alternatives are ranked in a descending order of C_i^* determined in Step 5.

ELECTRE

Step 1: Normalized Decision Matrix. We use the linear scale transformation as in the Simple Additive Weighting Method and TOPSIS.

Step 2: Weighted Normalized Decision Matrix. This step is the same as in TOPSIS.

Step 3: Concordance and Discordance Sets. Concordance Set: While comparing two alternatives A_a and A_b, a concordance set consists of all attributes for which the weighted normalized decision matrix values are equal or better. $C_{ab} = \{j \mid \mathbf{v}_{aj} \geq \mathbf{v}_{bj}\}$

Discordance Set: $D_{ab} = \{j \mid \mathbf{v}_{aj} < \mathbf{v}_{bj}\}$

Step 4: Concordance Matrix .The elements of this fuzzy matrix are defined as, $c_{ab} = \sum_{j = C_{ab}} \mathbf{w}_j$

The concordance matrix then becomes a (m x m) matrix shown in Table 6.

Step 5: Discordance Matrix An element of this matrix is defined as:

$$d_{ab} = \left[\max_{j \in D_{ab}} | \mathbf{v}_{aj} - \mathbf{v}_{bj} | \right] / \left[\max_{j \in J} | \mathbf{v}_{aj} - \mathbf{v}_{bj} | \right]$$

The elements d_{ab} are not fuzzy because we propose to use Zadeh's [7] separation measure to determine the numerator and denominator which result in crisp numbers. The discordance matrix then becomes as shown in Table 7.

Step 6: Concordance Dominance Matrix. First we determine a threshold value $\bar{c}$ as,

$$\bar{c} = \sum_{\substack{a=1 \\ a \neq b}}^{m} \sum_{\substack{b=1 \\ b \neq a}}^{m} c_{ab} / [m(m-1)]$$; Using $\bar{c}$, a matrix F is formulated with element f_{ab} where,

$f_{ab} = 1$, if $c_{ab} \geq \bar{c}$; and $f_{ab} = 0$, if $c_{ab} > \bar{c}$

Step 7: Discordance Dominance Matrix. A threshold index $\bar{d}$ is defined as,

$$\bar{d} = \sum_{\substack{a=1 \\ a \neq b}}^{m} \sum_{\substack{a=1 \\ a \neq b}}^{m} d_{ab} / [m(m-1)]$$. Then using $\bar{d}$, a matrix G is defined with elements g_{ab} where,

$g_{ab} = 1$, if $d_{ab} \leq \bar{d}$; and $g_{ab} = 0$, if $d_{ab} > \bar{d}$

Step 8: Aggregate Dominance Matrix. The matrix E with elements e_{ab} is defined where, $e_{ab} = f_{ab} \cdot g_{ab}$

Step 9: Less Favorable Alternatives. If $e_{ab} = 1$, using the aggregate dominance matrix, A_a is preferred to A_b. In this way the less favorable alternatives are eliminated.

EXAMPLE

We use an example of comparing five different types of car models. The data for this example are from the Consumer Reports [1] and The Car Book [6]. Whenever any data were missing, they have been estimated. The raw data and the fuzzy modeling are shown in Tables 8 and 9.

DISCUSSION

Normalization of Weights: In crisp algorithms generally the relative weights are chosen such that the sum of all weights is equal to one. If imprecise weights are to be modeled using fuzzy trapezoidal numbers, then it is mathematically impossible to make the sum of weights equal to 1 or [1, 1, 1, 1], unless we have the unusual situation of all four parameters of all weights being equal, in which case all the weights will become crisp. This is due to the nature of the trapezoidal fuzzy number. To resolve this, in our example, we make only the last parameter of the sum of weights equal to 1.

Methods of Comparing Fuzzy Numbers: We have proposed the use of the Lee and Li [4], and the Dubois and Prade [2] methods for comparison of fuzzy numbers. These two methods were chosen to present approaches from a stand-point of both possibility and probability. Generally we found the Lee and Li [4] method to be easier to use than the Dubois and Prade [2] method. The Dubois and Prade [2] method can at times give different orders using the four indices. This problem can be resolved using any crisp MADM method. In our example on ELECTRE, we use arithmetic average of these four indices in order to determine concordance and discordance sets.

Variation in Concepts: In our effort to fuzzify the previous MADM methods, we have tried to maintain the basic concepts presented for crisp methods as summarized in Hwang and Yoon [3]. We have deviated from the crisp methodology only to make our proposed approach computationally attractive, without any loss of mathematical logic. For example, in our approach to fuzzify TOPSIS and ELECTRE, we have preferred the linear scale transformation over vector normalization only to avoid computational complexity due to the use of extension principle. Another advantage is that all attributes are converted into benefit attributes for the remaining steps.

We thus avoid keeping track of which attributes are benefit or cost attributes. In our approach on TOPSIS, we use Zadeh's [7] separation measure for the city block index. This is made possible only because the normalized fuzzy weighted decision matrix is numerically less than one.

Comparison of Proposed Methods: We find that of the four fuzzified methods, the Simple Additive Weighting and Linear Assignment methods are the easiest to use. They are followed by TOPSIS, with ELECTRE being the most difficult due to the many steps.

Summary of Example: A summary of results of the same example solved using the proposed methods under the two different methods of comparing fuzzy numbers is provided in Table 10. The results show that the two methods of comparison result in the same order when using a particular method. Also, all the methods select the same top three alternatives.

TABLE 1

$$\mathbf{D} = \begin{array}{c|cccc} & X_1 & X_2 & - & X_n \\ A_1 & \mathbf{x}_{11} & \mathbf{x}_{12} & - & \mathbf{x}_{1n} \\ A_2 & \mathbf{x}_{21} & \mathbf{x}_{22} & - & \mathbf{x}_{2n} \\ - & - & - & - & - \\ A_m & \mathbf{x}_{m1} & \mathbf{x}_{m2} & - & \mathbf{x}_{mn} \end{array}$$

TABLE 2

$$\mathbf{D'} = \begin{array}{c|cccc} & X_1 & X_2 & - & X_n \\ A_1 & \mathbf{r}_{11} & \mathbf{r}_{12} & - & \mathbf{r}_{1n} \\ A_2 & \mathbf{r}_{21} & \mathbf{r}_{22} & - & \mathbf{r}_{2n} \\ - & - & - & - & - \\ A_m & \mathbf{r}_{m1} & \mathbf{r}_{m2} & - & \mathbf{r}_{mn} \end{array}$$

TABLE 3

Rank	X_1	X_2	-	X_n
lst	A_I	- _	-	-
2^{nd}	-	-	-	-
-	-	-	-	-
mth	-	-	-	A_C

TABLE 4

$$\boldsymbol{\pi} = \begin{array}{c|cccc} \text{Rank} & 1 & 2 & - & m \\ A_1 & \boldsymbol{\pi}_{11} & \boldsymbol{\pi}_{12} & - & \boldsymbol{\pi}_{1m} \\ A_2 & \boldsymbol{\pi}_{21} & \boldsymbol{\pi}_{22} & - & \boldsymbol{\pi}_{2m} \\ - & - & - & - & - \\ A_m & \boldsymbol{\pi}_{m1} & \boldsymbol{\pi}_{m2} & - & \boldsymbol{\pi}_{mm} \end{array}$$

TABLE 5

$$\mathbf{V} = \begin{array}{c|cccc} & X_1 & X_2 & - & X_n \\ A_1 & \mathbf{v}_{11} & \mathbf{v}_{12} & - & \mathbf{v}_{1n} \\ A_2 & \mathbf{v}_{21} & \mathbf{v}_{22} & - & \mathbf{v}_{2n} \\ - & - & - & - & - \\ A_m & \mathbf{v}_{m1} & \mathbf{v}_{m2} & - & \mathbf{v}_{mn} \end{array}$$

TABLE 6

$$\mathbf{C} = \begin{array}{ccccc} - & \mathbf{c}_{12} & \mathbf{c}_{13} & - & \mathbf{c}_{1m} \\ \mathbf{c}_{21} & - & \mathbf{c}_{23} & - & \mathbf{c}_{2m} \\ - & - & - & - & - \\ - & - & - & - & - \\ \mathbf{c}_{m1} & \mathbf{c}_{m2} & - & - & - \end{array}$$

TABLE 7

$$\mathbf{D}_x = \begin{array}{ccccc} - & \mathbf{d}_{12} & \mathbf{d}_{13} & - & \mathbf{d}_{1m} \\ \mathbf{d}_{21} & - & \mathbf{d}_{23} & - & \mathbf{d}_{2m} \\ - & - & - & - & - \\ \mathbf{d}_{m1} & \mathbf{d}_{m2} & - & - & - \end{array}$$

TABLE 8

Raw Data for 5 Automobiles for Attributes X_1 through X_3

Alternative	Crash Test X_1 (L/B)	Price X_2	Fuel Exp./yr. X_3
Corvette (A_1)	2010*	29480	907
Cadillac (A_2) Fleetwood	3017**	34750	789
Honda (A_3) Civic	(N/A) 1838@	8515	484
Lincoln (A_4) Mark 7	(N/A) 2717@@	25068	750
Toyota (A_5) Celica	1797	15618	536
Weights X 10^2	(11,12,14,15)	(27,28,29,30)	(8,9,9.5,10)

L/B Lower, Better * Camaro @ Ford Escort
** Buick LeSabre @@Ford LTD

TABLE 9 Raw Data for 5 Automobiles for Attributes X_4 through X_7

Alternative	Insurance X_4	Maintenance X_5	Reliability X_6	Ride X_7
Corvette (A_1)	N/A Surcharge Assumed	N/A High Assumed	Much Worse than average	N/A Stiff* Assumed
Cadillac Fltw. (A_2)	Discount	High	Worse than Average	N/A Very Comfortable **
Civic (A_3)	Regular	Regular (Medium)	Much Better than Average	Tolerable for Long Trips @
Lincoln M 7 (A_4)	Regular	High	Average	Well Controlled & Smooth Ride @@
Toyota Cel. (A_5)	Surcharge	Medium	Much Better than Average	Well Controlled & Smooth Ride
Weights X 10^2	(5, 6, 8, 10)	(2, 3, 4.5, 5)	(17, 18, 19, 20)	(7.5,8,9.5,10)

* Camaro Rating @ Ford Escort Rating
** Buick LeSabre Rating @@ Ford LTD Rating

TABLE 10 Summary of Example

Proposed Fuzzy Method	Results Using Comparison Methods of Lee and Li	Dubois and Prade
Simple Additive Weighting	A_3, A_5, A_4, A_2, A_1	A_3, A_5, A_4, A_2, A_1
Linear Assignment	A_3, A_5, A_4, A_1, A_2	A_3, A_5, A_4, A_1, A_2
TOPSIS	A_3, A_5, A_4, A_2, A_1	A_3, A_5, A_4, A_2, A_1
ELECTRE	A_3, A_5, A_4, A_2, A_1	A_3, A_5, A_4, A_2, A_1 A_1, A_2

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ESTIMATING REFERENCE EVAPOTRANSPIRATION USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Reference evapotranspiration (ET_0) is an important aspect of irrigation scheduling and hydrologic studies in the study of loss of water from a cropped field and hence the overall water requirements for agricultural crops in a particular geography. The Penman-Monteith equation is a widely used method for estimation of ET_0. The objective of this study is to use artificial neural networks (ANNs) to estimate ET_0 with a limited number of weather parameters data available. The ten year dataset was split into training & verification datasets in the ratios 50:50, 60:40, 70:30 and 80:20. The network was trained and verified using a genetic algorithm for 9 different combinations of variables. This was further validated with three year data from the Calipatra weather station.

KEYWORDS

Reference Evapotranspiration Coefficient, Neural Networks, Genetic Algorithm, Penman-Monteith, estimating evapotranspiration

INTRODUCTION

The estimation of reference crop evapotranspiration (ET_0) is of utmost importance for watershed studies and irrigation water requirements. In recent years Artificial Neural Networks (ANNs) have been widely used for modeling and forecasting time series data [4] [9] [10]. Their application to estimating reference ET_0 has been limited [5] [8].

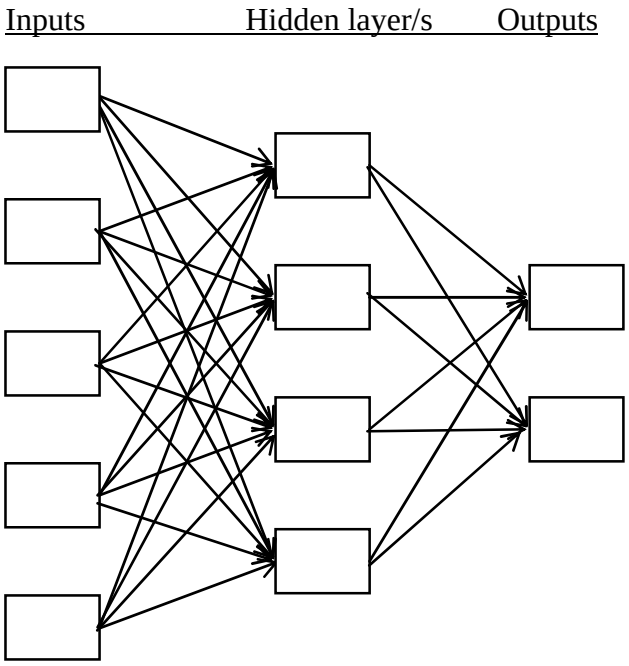
Artificial neural networks are relatively crude electron models based on the neural structure of the brain. The brain basically learns from experience. It is a natural proof that some problems that are beyond the scope of current computes are indeed solvable using small energy efficient packages. It is gaining popularity in the field of hydrology although this technique is in its nascent stage. The method of (ANNs) used in this paper is genetic algorithms. Genetic algorithms are search algorithms based on the mechanism of natural selection and natural genetics-defined by Goldberg [2].

In this paper the ANN is applied to estimate the daily values of ET_0 for the Davis weather station in California. Ten years of data containing daily values of weather parameters such solar radiation, precipitation, average wind speed, etc. were obtained. The data set was split into training and verification in ratios of 50:50, 60:40, 70:30 and 80:20.The network was trained and tested using the genetic algorithm for the different combinations of input variables and compared with the Penman-Monteith method for estimating ET_0. The Penman-Monteith equation is widely regarded as one of the most accurate models, in terms of estimating ET_0 and recommended as the method to use by the FAO [1].

ARTIFICIAL NEURAL NETWORKS (ANN) & GENETIC ALGORITHMS (GA)

Neural networks are a different paradigm of computing, inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems.

Fig. 1 A Schematic Diagram of the ANN



Thus, they are a form of multiprocessor computer system, with

- simple processing elements
- a high degree of interconnection
- simple scalar messages
- adaptive interaction between elements

Genetic algorithms (GAs) are adaptive heuristic search algorithms premised on the evolutionary ideas of natural selection and genetic. The basic concept of GAs is designed to simulate processes in natural systems necessary for evolution, specifically those that follow the principles first laid down by Charles Darwin as survival of the fittest. As such they represent an intelligent exploitation of a random search within a defined search space to solve a problem.

The genetic algorithm creates a population of genomes then applies crossover and mutation to the individuals in the population to generate new individuals. It uses various selection criteria so that it picks the best individuals for mating (and subsequent crossovers).

In recent years the American Society for Civil Engineers (ASCE) has recorded a substantial number of research and application papers with respect to the use of ANNs, genetic algorithms in particular, in areas like irrigation & drainage, hydrology and water resources planning and management [6].

MODELING PROCESS

Database

Fourteen dependent variables were identified on which the study was conducted [3] [7]. Nine different combinations of these variables were taken intuitively, to train the network as shown in Table 1.

The daily values of weather parameters were taken from the Davis and Calipatria weather stations in California (Table 2). The estimated ET_0 values by the Penman-Monteith method for the same data were available at the California Irrigation Management Information System (CIMIS) for the same stations.

Table 1 - Variables, Units and Their Combinations

Sr. No.	Variables	Units	Combination								
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Day of the year	1st January = 1				+					
2	Dew Pt	°F				+		+			
3	Precipitation	In				+		+			
4	Minimum Relative Humidity	%				+					
5	Max Relative Humidity	%				+		+			
6	Average Relative Humidity	%	+	+		+				+	
7	Minimum Air Temperature	°F				+				+	
8	Maximum Air Temperature	°F				+		+		+	
9	Average Air Temperature	°F	+	+	+	+				+	+
10	Average Vapor Pressure	mBars				+		+			
11	Average Soil Temperature	°F				+		+		+	
12	Average wind Speed	Mph	+	+		+			+	+	
13	Wind Run	Miles				+		+			
14	Solar Radiation	Ly/day	+			+	+		+	+	+

Table 2 - Database Specifications

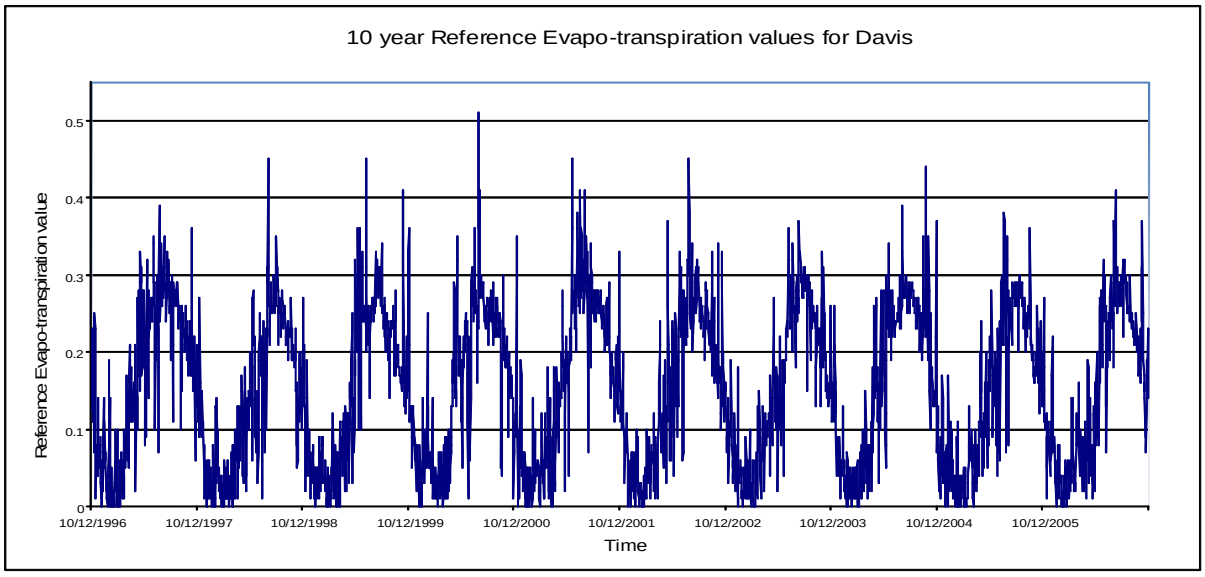
Weather Station	Davis	Calipatria
Elevation (ft)	60	-110
Latitude	38° 32' 09" N	33° 02' 37" N
Longitude	121° 46' 32" W	115° 24' 56" W
Time Range of the Data	1996-2006	a. 1997-1998 b. 2001-2002 c. 2004-2005
Data used for	Network training Network verification	Network validation
Ratios of Data Splits used	a. 50:50 b. 60:40 c. 70:30 d. 80:20	Not Applicable

Network Training

The supervised learning strategy is used to train the network. As the data is cyclical in nature, it is randomly split into training and verification data-sets. The same dataset is split into 4 different pre-defined ratios as mentioned in Table 1. The 4 different splits are subjected to 9 combinations of input variables, resulting in 36 different network trainings.

The first part of each ratio is used to train the network. The network is trained until there are no improvements for 100 generations. The importance of each input variable is recorded on a scale of 40. The (1) network performance, (2) average error and (3) the estimated values are other important outputs generated. The residual error and sum of squares residual are calculated as discussed in the Findings & Discussion section.

Fig. 2 - 10 Year Reference Evapotranspiration Values for the Davis Weather Station



NETWORK VERIFICATION

The second part of the split, which was not used in training the network, was used to verify the performance of the trained network. The trained network estimates the reference evapotranspiration coefficient for this dataset. These estimated values were compared to the actual values and the sum squares residual for the same dataset were calculated (Table 3).

Table 3 - Data Analysis with Artificial Neural Networks for the Davis Weather Station (1996-2006) for 9 Different Combinations of Variables

Data Split	Sr. No.	Variables	Combination								
			1	2	3	4	5	6	7	8	9
	1	Day of the year				+					
	2	Dew Pt				+		+			
	3	Precipitation				+		+			
	4	Min Rel. Humidity				+					
	5	Max Rel. Humidity				+		+			
	6	Avg Rel. Humidity	+	+		+				+	
	7	Min Air Temp.				+				+	
	8	Max Air Temp.				+		+		+	
	9	Avg Air Temp.	+	+	+	+				+	+
	10	Avg Vapor Press.				+		+			
	11	Avg Soil Temp.				+		+		+	
	12	Avg wind Speed	+	+		+			+	+	
	13	Wind Run				+		+			
	14	Solar Radiation	+			+	+		+	+	+
50:50	Network performance		**0.983**	0.894	0.747	**0.988**	0.888	0.912	**0.934**	0.982	0.920
	Average Error		**0.008**	0.025	0.039	**0.007**	0.021	0.023	0.018	**0.008**	0.072
	Training SSR		**0.314**	1.928	4.593	**0.211**	2.025	1.593	1.199	0.318	**0.211**
	Verification SSR		**0.325**	1.720	4.356	**0.244**	1.847	1.591	1.196	0.355	**0.244**
60:40	Network performance		**0.983**	0.896	0.744	**0.988**	0.890	0.911	0.934	**0.984**	0.922
	Average Error		**0.008**	0.025	0.038	**0.007**	0.021	0.023	0.017	**0.008**	0.017
	Training SSR		**0.343**	2.209	5.442	**0.238**	2.330	1.895	1.398	**0.337**	1.655
	Verification SSR		**0.236**	1.420	3.510	**0.187**	1.540	1.230	**0.990**	1.420	1.090
70:30	Network performance		**0.985**	0.902	0.721	**0.986**	0.856	0.913	0.936	**0.986**	0.922
	Average Error		**0.007**	0.024	0.032	**0.007**	0.023	0.022	0.017	**0.007**	0.017
	Training SSR		**0.357**	2.416	6.875	**0.331**	3.550	2.140	1.582	**0.323**	1.926
	Verification SSR		**0.153**	1.019	2.770	**0.152**	1.207	0.926	0.750	**0.143**	0.695
80:20	Network performance		**0.984**	0.900	0.747	**0.990**	0.893	0.912	0.934	**0.985**	0.933
	Average Error		**0.007**	0.024	0.030	**0.007**	0.021	0.022	0.018	**0.007**	0.016
	Training SSR		**0.445**	2.795	4.593	**0.291**	3.008	2.480	1.871	**0.428**	1.874
	Verification SSR		**0.142**	0.771	4.356	**0.114**	0.878	0.630	0.522	**0.138**	0.567

NETWORK VALIDATION

The verification data-set though not used in training the network, was from the same weather station as the training data-set. To study the universality of the trained network, it is used to estimate values from a different weather station (Calipatria).

Table 4 - Data Validation with Artificial Neural Networks for the Imperial Valley Weather Station (Selected Years) for 9 Different Combinations of Variables

Data Split	Sr. No.	Variables	Combination								
			1	2	3	4	5	6	7	8	9
	1	Day of the year				+					
	2	Dew Pt				+		+			
	3	Precipitation				+		+			
	4	Min Rel. Humidity				+					
	5	Max Rel. Humidity				+		+			
	6	Avg Rel. Humidity	+	+		+				+	
	7	Min Air Temp.				+				+	
	8	Max Air Temp.				+		+		+	
	9	Avg Air Temp.	+	+	+	+				+	+
	10	Avg Vapor Press.				+		+			
	11	Avg Soil Temp.				+		+		+	
	12	Avg wind Speed	+	+		+			+	+	
	13	Wind Run				+		+			
	14	Solar Radiation	+			+	+		+	+	+
50:50	1997-98	Validation SSR	**0.084**	0.599	1.186	**0.136**	0.615	0.783	0.653	**0.099**	0.302
	2001-02	Validation SSR	**0.066**	0.721	1.481	**0.064**	0.236	0.873	0.226	**0.088**	0.453
	2004-05	Validation SSR	**0.075**	0.271	0.605	0.248	**0.096**	0.309	**0.073**	0.564	1.028
60:40	1997-98	Validation SSR	**0.050**	0.620	1.160	**0.080**	0.630	0.610	0.640	0.620	**0.310**
	2001-02	Validation SSR	**0.050**	0.710	1.480	**0.070**	0.230	0.750	**0.220**	0.710	0.490
	2004-05	Validation SSR	**0.070**	0.540	0.970	**0.070**	0.270	0.580	**0.240**	0.540	0.330
70:30	1997-98	Validation SSR	**0.086**	0.574	1.119	**0.093**	0.641	0.608	0.650	**0.092**	0.388
	2001-02	Validation SSR	**0.093**	0.617	1.421	**0.110**	0.233	0.749	0.230	**0.091**	0.722
	2004-05	Validation SSR	**0.094**	0.515	0.931	**0.101**	0.264	0.495	0.240	**0.085**	0.420
80:20	1997-98	Validation SSR	**0.078**	0.597	1.028	**0.093**	0.636	0.629	0.660	**0.074**	0.562
	2001-02	Validation SSR	**0.099**	0.691	1.271	**0.097**	0.237	0.717	0.229	**0.085**	0.370
	2004-05	Validation SSR	**0.094**	0.544	0.857	**0.089**	0.237	0.490	0.251	**0.087**	0.808

FINDINGS & DISCUSSION

The three best readings are presented in Table 3 for each parameter of (1) network performance, (2) average error, (3) sum of squares residual of training data prediction and (4) sum of squares residual of the verification data for the Davis weather station. Similar readings of sum of squares residual of the validation data prediction for the Calipatria weather station are presented in Table 4. Though combination 4, which includes all the variables, seems better than combination 1 during the training and verification process, it fails to predict the ET_0 coefficient as efficiently as combination 1 for a completely new data set, which is not used for training the network. This suggests robustness of network 1.

CONCLUSIONS

Thus it can be concluded that combination 1 which consists of 4 variables (1) average relative humidity (2) average air temperature (3) average wind speed and (4) solar radiation is a good compromise between the number of variables used and prediction accuracy. Also, the type of splits has no effect on training / verification or validation of the network and determining its overall efficacy.

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FUZZY CRITICAL PATH ANALYSIS

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ABSTRACT

This paper presents a new methodology for fuzzy critical path analysis that is consistent with the extension principle of fuzzy logic. It is the direct generalization of critical path analysis from the crisp to the fuzzy domains, and resolves some of the problems expressed in the literature, especially in computing the fuzzy backward recursion of the project network and fuzzy activity criticality. We present a mathematical programming procedure that constructs the membership function for the fuzzy set of critical path lengths and the fuzzy activity criticality. Computational results from applying this method to well-known problem sets are reported.

Keywords: project management, project scheduling, critical path analysis, fuzzy sets, mathematical programming

Introduction

Fuzzy logic is an approach for measuring imprecision or vagueness in estimation, and may be preferred to probability theory in capturing activity duration uncertainty when past data is either unavailable or not relevant, the definition of the activity itself is somewhat unclear, or the notion of the activity's completion is vague. Chanas and Kuchta [1] describe two approaches for applying the forward project network recursion, and indicate that the application of the backward recursion would cause a considerable increase in the range of uncertainty in the start and finish times. Some authors have proposed modifications of the backward recursion [6] [8] [10].

Chanas and Zielinski [2] present a method for analyzing the degree of criticality of the fuzzy paths in the project network using interval activity times. These authors show that the computation of the possible criticality of activities is computationally complex [3]. Some methods for determining the necessary (surely) criticality of paths are found in [4]. Dubois et al. [5] concluded that "a rigorous and complete criticality analysis of fuzzy PERT networks is still to be carried out…"

PROJECT NETWORK AND CRITICAL PATH CONCEPTS

Let $A = \{a_1, a_2, ..., a_N\}$ be the set of project activities. Let B_i, *i=1,2,…,N*, $B_i \subset A$, be defined so that the elements of B_i are the immediate predecessors of a_i. We let $B = \{B_1, B_2, ..., B_N\}$ be the set of predecessor sets. *A* and *B* define the network structure or graph *G* of a project.

We initially assume that $t_i \in \mathbb{R}$, $t_i \geq 0$, is the certain or *crisp* duration for a_i, where

$T = \{t_1, t_2, ..., t_N\}$. The length of the longest path in the project network is the *critical path,* the activities along it are called *critical path activities,* and the length of the path is denoted as L_{CP}.

The forward recursion of the project network requires computing the earliest start (ES) and the earliest finish (EF) for each activity, while the backward recursion requires computing the latest start (LS) and latest finish (LF). Once both recursions are completed the activity total float or slack (S) can be computed.

Given *G* for each unique set of values *T* we can compute L_{CP}. Therefore, there is a function *f(T|G):* $\mathbb{R} \times \mathbb{R} \times ... \times \mathbb{R} \to \mathbb{R}$ that maps *T* to L_{CP}, or $L_{CP} = f(T|G)$. Similarly there exists functions $g_i(T|G)$ that map *T* to $ES_i, EF_i, LS_i, LF_j,$ and S_i.

FUZZY CRITICAL PATH SOLUTION APPROACH

A fuzzy set M is a subset of the universe *U* that is characterized by a membership function μ_M : $U \to [0,1]$ such that: $\mu_M(x) = 0$, if *x* certainly is not a member of *M,* $\mu_M(x) = 1$, if *x* certainly is a member of *M,* $\mu_M(x) \in (0,1)$ if it is uncertain whether *x* is a member of *M,* where $\mu_M(x)$ represents the degree to which *x* is a member of *M.* A fuzzy number *M* is a fuzzy subset of $\mathbb{R}$ with membership function $\mu_M : \mathbb{R} \to [0,1]$ such that

$$\sup(\mu_M(x) : x \in \mathbb{R}) = 1 \tag{1a}$$

$$\exists x_1^M, x_2^M \in \mathbb{R}, x_1^M < x_2^M : \forall x \in \mathbb{R}, \quad x \notin (x_1^M, x_2^M) \Rightarrow \mu_M(x) = 0 \tag{1b}$$

Applying the extension principle [11] to the fuzzy critical path problem yields:

Proposition 1. Fuzzy Critical Path Membership Function
The membership function for the fuzzy critical path length can be determined as:

$$\mu_{CP}(L_{CP}) = \underset{t_1, t_2, ..., t_N}{Max} \quad \underset{i \in \{1,2,...,N\}}{Min} \quad \{\mu_i(t_i)\} \tag{2}$$
$$f(t_1, t_2, ..., t_N \mid G) = L_{CP}$$

where $\mu_{CP}(L_{CP})$ is the membership function for the length of the critical path over the fuzzy subset *CP* in $\mathbb{R}$; and for a graph *G* and activity durations $t_1, t_2, ..., t_N$, $f(t_1, t_2, ..., t_N \mid G)$ determines the length of the critical path.

Suppose a given combination of possible activity times $t_1, t_2, ..., t_N$ leads to a specific critical path length L_{CP}. According to Proposition 1, the belief associated with this combination is the minimum of the $\mu_i(t_i)$, the beliefs of the possible activity times. Since there may be more than

one combination of $t_1, t_2, ..., t_N$ that leads to L_{CP}, the maximum of the beliefs of all combinations of activity times leading to L_{CP} must be taken to determine the belief of L_{CP}.

Similarly, there exists functions $g_i(T|G)$: $\mathbb{R} \times \mathbb{R} \times ... \times \mathbb{R} \rightarrow \mathbb{R}$ that map T to the slack of a_i, or $S_i = g_i(T|G)$. We define $\mu_{S_i}(0)$ as the fuzzy criticality of a_i.

Several solution approaches are possible, including enumerating all possible sets of activity times and determining their critical path lengths and activity criticalities. A more attractive approach is to apply mathematical programming.

MATHEMATICAL PROGRAMMING SOLUTION

Determining the Fuzzy Set of Critical Path Lengths

Equation (2) can be converted into the following nonlinear programming problem:

$$\text{Max } \mu_{CP}(L_{CP,s}) = \max \left\{ \min_{i=1,2,...,N} \sum_{k=1}^{n_i} y_{i,k} u_{i,k} \right\} \quad (3)$$

subject to:

$$\sum_{k=1}^{n_i} y_{i,k} = 1, i = 1, 2, ..., N \quad (4)$$

$$ES_1 = 0 \quad (5)$$

$$ES_i = \max_{j \in b_i} \left\{ ES_j + \sum_{k=1}^{n_i} y_{j,k} t_{j,k} \right\}, i = 2, 3, ..., N \quad (6)$$

$$ES_N = L_{CP,s} \quad (7)$$

$$y_{i,k} \text{ binary, } i=1,2,\ldots,N,\ k= 1,2,\ldots,n_i \quad (8)$$

Note that $y_{i,k} = 1$ if a_i takes on the k^{th} possible length $t_{i,k}$ and belief $u_{i,k}$, and 0 otherwise, leading to (4). ES_i is computed using the selected $t_{i,k}$ in equation (6). The belief associated with the set of $y_{i,k} = 1$ is the minimum of the $u_{i,k}$. In equation (3) the mathematical program seeks to maximize the belief of the selected $t_{i,k}$ such that the length of the critical path equals the specified value $L_{CP,s}$ as given in equation (7). This problem must be solved for all $L_{CP,s}$, $s=1,2,\ldots,n_{CP}$, where n_{CP} is the number of possible critical path lengths. The minimum and maximum possible critical path lengths are determined by performing standard CPM analyses assuming that the smallest and largest possible durations occur for each activity, respectively. $L_{CP,s}$ ranges between the resulting minimum and maximum critical path lengths.

The equivalent mixed binary linear programming problem (MBLP1) is:

MBLP1

$$Max\ \mu_{CP}(L_{CP,s}) \tag{9}$$

Subject to:
Equations (4), (5), (7), (8) and

$$\mu_{CP}(L_{CP,s}) \le \sum_{k=1}^{n_i} y_{i,k} u_{i,k}, i = 1,2,...,N \tag{10}$$

$$ES_i \le ES_j + \sum_{k=1}^{n_i} y_{j,k} t_{j,k} + (1 - p_{ij})M,\ j \in B_i, i = 2,3,...,N \tag{11}$$

$$ES_i \ge ES_j + \sum_{k=1}^{n_i} y_{j,k} t_{j,k},\ j \in B_i, i = 2,3,...,N \tag{12}$$

$$\sum_{j \in b_i} p_{ij} = 1, i = 2,3,...,N \tag{13}$$

$$p_{ij} \text{ binary},\ j \in B_i, i = 2,3,...,N \tag{14}$$

where *M* is a large number.

In MBLP1, equation (10) turns the minimization in equation (3) into a series of constraints, while using standard conversion techniques allows equations (11) – (14) to replace equation (6). $p_{ij} = 1$ if ES_i equals the ES_j, where *j* is one of *i*'s predecessors, plus one of the possible durations of a_j.

Determining the Fuzzy Activity Criticalities

To obtain the fuzzy criticality of a_{i^*} we need to augment MBLP1 by adding constraints to compute LS_i, LF_i, and $S_{i.}$. As in MBLP1 after using a conversion technique for the equation for LS_j we obtain the following formulation:

MBLP2

$$Max\ \mu_{S_i}(0) \tag{15}$$

Subject to equations (4), (5), (7), (8), (11) – (14) and:

$$\mu_{S_i}(0) \le \sum_{k=1}^{n_i} y_{i,k} u_{i,k}, i = 1,2,...,N \tag{16}$$

$$LS_j - \sum_{k=1}^{n_i} y_{j,k} t_{j,k} - (1 - q_{ij})M \le LS_i,\ j \mid i \in B_j, i = 1,2,...,N-1 \tag{17}$$

$$LS_i \le LS_j - \sum_{k=1}^{n_i} y_{i,k} t_{i,k}, \; j \mid i \in B_j, i = 2,3,...,N-1 \tag{18}$$

$$\sum_{j \mid i \in B_j} q_{ij} = 1, i = 1,2,...,N-1 \tag{19}$$

$$q_{ij} \text{ binary}, \; j \mid i \in B_j, i = 1,2,...,N-1 \tag{20}$$

$$LS_N = ES_N \tag{21}$$

$$S_{i^*} = LS_{i^*} - ES_{i^*} = 0 \tag{22}$$

Proposition 2: Assume the duration of each activity in a project network *G* is set to the possible value whose belief is one. Also assume that after conducting a standard CPM analysis using these durations, the slack for some activity a_{i^*} is zero. Then the fuzzy criticality of a_{i^*} is one. Also, the resulting critical path length has a belief of one.

The activities whose fuzzy criticalities are one can be skipped when applying MBLP2.

ANALYSIS OF TEST CASES

Problem Sets

The Patterson problem set [9] was adapted so that it could be used to test the solution approach. A set of 35 test problems with up to 51 activities were identified. In addition, four larger problems were drawn from a project management library called PSPLIB [7], including two having 62 activities and two having 92 activities. Since the Patterson and PSPLIB problems have crisp (non-fuzzy) activity durations, a set of possible activity times and associated beliefs were developed for each activity within each problem.

Computational Results

CPLEX 9.0 mathematical programming software was used to implement MBLP1 and MBLP2. All of the 39 test problems were solved completely. Twenty-two problems were solved in less than five seconds of CPU time, and 26 were solved in less than 30 seconds. Three of the Patterson problems that have relatively larger network complexity ratios were somewhat more difficult to solve. The largest problems in the test set generally took more time to solve unless the network complexity was relatively low.

CONCLUSIONS

A three-step mathematical programming procedure that constructs the membership function for the fuzzy set of critical path lengths and fuzzy activity criticality was developed. Using this procedure the fuzzy set of path criticalities can also be determined. The proposed method was tested on a subset of the Patterson problems and some larger problems from PSPLIB and is shown to offer computation times that should allow its use in practice to better understand project schedule uncertainty.

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WHERE DO EUROPEAN UNION NATIONS STAND? – AN ANALYTICAL ANALYSIS USING DATA ENVELOPMENT ANALYSIS

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ABSTRACT

This study measures the effectiveness of the integration of Europe by benchmarking economic progress made by participating nations by the fifteen participating nations. Using data envelopment analysis approach, this study compares the relative performance of EU 15 nations against one another with seven economic variables as the benchmark parameters from 1993 to 2006. This study finds that there is lack of convergence in the performance of EU 15 nations and some nations have performed more efficiently in contrast to other nations. The study points out the member nations that are lagging behind and make recommendations as to how they can improve their performance to bring them at par with other participating nations.

INTRODUCTION

In recent years, regional economic integration has grown. There are at least twelve regional integrated areas in the world with the European Union being the oldest and the most integrated. European Union was created with a promise of peace and prosperity in terms of higher GDP growth rates through free market trade within the union, lower inflation through monetary policy coordination and lower budgetary deficits, lower currency volatility through single currency, promotion of democratic institutions through respect for human rights and peace on borders of the participating nations. This study measures the effectiveness of the integration of Europe by benchmarking economic progress made by the original fifteen participating nations. In this paper, we use the *Data Envelopment Analysis* methodology to assess the relative performance of the 15 EU nations from 1993 to 2006. This paper builds on a previous study by Malhotra, Malhotra, and Mariotz (2005) in which they benchmark European Union nations for the year 2004 only. We distinguish current study from MMM (2005)'s study by adopting a much larger database from 1993 to 2006. By benchmarking European Union nations against one another for each of the last fourteen years, we will be able to find out if some nations have consistently performed well under the EU. By identifying the nations that have performed consistently well over a period of fourteen years, we can identify the factors that have contributed to their success so that other EU nations can structure their policies to benefit from economic integration. It will also help us track and understand the changes in performance of the EU over a period of time. Furthermore, we also investigate any trends in the performance of these countries over the last fourteen years.

Data Envelopment Analysis is a technique that can be used to assess the productive efficiency of homogenous operating units such as schools, hospitals, banks or utility companies. DEA approach is a powerful technique for performance measurement, because of its objectivity, ability to handle multiple inputs and multiple outputs that can be measured in different units. Also, in contrast to non-parametric techniques such as Stochastic Frontier, DEA approach does not require specification of any functional relationship between inputs and outputs or a priori specification of weights of inputs and outputs. DEA provides gross efficiency scores based on the effect of controllable and uncontrollable factors. Therefore, the purpose of this study is to develop data envelopment analysis models to study the efficiency of the EU nations.

The rest of the paper is organized along the following lines. Section II provides a summary of the previous literature on the European Union. We also include previous studies on applications of data envelopment analysis. In section III, we discuss the methodology used in this study. Section IV summarizes the empirical results. Section V provides summary and conclusion for this study.

PREVIOUS STUDIES

European Union Literature

Paliwoda (1997) present selected statistics on Central and Eastern Europe to reflect the respective levels of current economic performance as well as expert projections as to where these economies are headed. According to Paliwoda (1997), a common objective shared by many Central and Eastern European nations is membership of the European Union together with the NATO defense alliance, so as to be better able to consolidate economic and political gains made to date. Grimwade (1999) discusses the growth of the European Union and documents higher growth in the Eurozone after the integration. Wynne (2000) looks at how the economy of the euro area has fared under the single monetary policy, examines how successful the European Central Bank has been in fulfilling its mandate for price stability, and considers the prospects for the future. Despite the dramatic decline in the euro against the dollar over the course of 1999, the first year of EMU must be judged a success. Garcia-Mila and McGuire (2001) evaluate the seventeen regional governments of Spain that receive grants from the European Union. This study evaluates the effectiveness of these grants and finds that these policies have not been effective in stimulating private investment or improving the overall economies of the poorer regions. Amuedo-Dorantes and Wheeler (2001) examines the impact that the European Union (EU) has exerted on Spanish economic activity. The main finding of the analysis is that the EU has significant impacts on the Spanish economy. The paper finds that shocks to EU output explain up to 63% of Spanish output. At longer time horizons, shocks to the EU's inflation rate and output combine to explain over 50% of the forecast error variance in Spanish inflation. Gacs (2003) analyzes how much and to what direction the inherited structure of the Central and East European candidate countries was transformed in recent years, and what this shift meant for their real convergence in the enlarged EU. A rearrangement of historical importance occurred across the main sectors contributing to GDP, in the framework of which services have been emancipated. Salih (2004) argues that the road to EU as a nation will not be as smooth as some European countries would have hoped. Structural incompatibilities, political rivalry and speculator's behavior are some of the factors that will affect the performance and unification of Europe. Ultimately, cooperation between rival nations is a vital factor to a successful unification of Europe, better global well being and trade and development. Malhotra and Mariotz (2005) measure the effectiveness of the integration of Europe by evaluating economic and socioeconomic progress made by fifteen participating nations since the Maastricht Treaty. They find that on the economic front, member nations have made good progress during the post-Maastricht Treaty period. However, on the socio-economic front, during the post-Maastricht Treaty, many member nations show deterioration in the performance.

Data Envelopment Analysis Literature

Recently, many studies have illustrated the use of DEA, a non-parametric methodology to analyze different aspects of mutual funds. The details of the DEA model are discussed in the next section. In contrast to other methodologies, DEA is one of the methods that has traditionally been used

to assess the comparative efficiency of homogenous operating units such as schools, hospitals, utility companies, sales outlets, prisons, and military operations. More recently, it has been applied to banks (Haslem, Scheraga, & Bedingfield, 1999) and mutual funds (Haslem & Scheraga, 2003; Galagedera & Silvapulle, 2002; McMullen & Strong, 1998; Murthi, Choi, & Desai, 1997).

Murthi, Choi, & Desai (1997) examine the market efficiency of the mutual fund industry by different investment objectives. They use a benefit/cost non-parametric analysis where a relationship between return (benefit) and expense ratio, turnover, risk, and loads (cost) is established. They also develop a measure of performance of mutual funds that has a number of advantages over traditional indices. The DEA portfolio efficiency index (DEPI) does not require specification of a benchmark, but incorporates transaction costs. The most important advantage of DEA method as compared to other measures of fund performance is that DEA identifies the variables leading to inefficiencies and the levels by which they should be changed to restore the fund to its optimum level of efficiency. McMullen and Strong (1998) applied DEA to evaluate the relative performance of 135 US common stock funds using one, three, and five-year annualized returns, standard deviation of returns, sales charge, minimum initial investment, and expense ratio. They illustrate that DEA can assist in selecting mutual funds for an investor with a multifactor utility function. The DEA selects optimum combinations of investment characteristics, even when the desired characteristics are other than the two-factors specified in Capital Market Theory. The DEA enable the user to determine the most desirable alternatives, and pinpoint the inefficiencies in a DEA-inefficient alternative. Sedzro and Sardano (1999) analyzed 58 US equity funds in Canada using DEA with annual return, expense ratio, minimum initial investment and a proxy for risk as factors associated with fund performance. Further, they also find a strong relationship among the efficiency rankings using DEA, Sharpe ratios, and Morningstar data. Galagedera and Silvapulle (2002) use DEA to measure the relative efficiency of 257 Australian mutual funds. The further investigate the sensitivity of DEA efficiency to various input-output variable combinations. They find that more funds are efficient when DEA captures a fund's long-term growth and income distribution than a shorter time horizon. In general, the overall technical efficiency and the scale efficiency are higher for risk-aversive funds with high positive net flow of assets.

Haslem and Scheraga (2003) use DEA to identify efficiencies in the large-cap mutual funds in the 1999 Morningstar 500. They identify the financial variables that differ significantly between efficient and inefficient funds, and determine the nature of the relationships. They use Sharpe index as the DEA output variable. They find that the input/output and profile variables are significantly different between the Morningstar 500 (1999) large-cap mutual funds that are DEA performance-efficient and inefficient. Basso and Funari (2001) propose the use of DEA methodology to evaluate the performance of mutual funds. The proposed DEA performance indexes for mutual funds represent a generalization of various traditional numerical indexes that can take into account several inputs and outputs. They propose two classes of DEA indexes. The first class generalizes the traditional measures of evaluation using different risk indicators and subscription and redemption costs that burden the fund investment. The second class of indexes considers a multiple inputs-outputs structure. Thus, they monitor not only the mean return but also other features such as stochastic dominance and the time lay-out. Morey and Morey (1999) present two basic quadratic programming approaches for identifying those funds that are strictly dominated, regardless of the weightings on different time horizons being considered, relative to their mean returns and risks. They present a novel application of the philosophy of data envelopment analysis that focuses on estimating "radial" contraction/expansion potentials. Furthermore, in contrast to many studies of mutual fund's performance, their approach endogenously determines a custom-tailored benchmark portfolio to which each mutual fund's performance is compared.

Using data envelopment analysis approach, Malhotra, Malhotra, and Mariotz (2005) compare the relative performance of EU 15 nations against one another with seven economic variables as the

benchmark parameters. This study finds that there is lack of convergence in the performance of EU 15 nations and some nations have performed more efficiently in contrast to other nations. The purpose of this study is to investigate and analyze the relative performance of the original participating countries in the European Union. Using the economic data from 1993-2006, this study illustrates the use of data envelopment analysis (DEA) to evaluate the homogeneity of benefits of integration across the members of the European Union over the last fourteen years.

METHODOLOGY

The European Union has been built to achieve political goals, but its dynamism and success spring from its economic foundations-the 'single market' formed by all the EU member states, and the single currency (the euro) used by 12 of them. The EU as a unit has much more economic, social, technological, commercial and political 'clout' than the individual efforts of its member states, even when taken together. There is added value in acting as one and speaking with a single voice as the European Union.

The European Council established three major criteria for acceptance into the Union. First, a political criterion: candidate countries must have stable institutions guaranteeing democracy, the rule of law, human rights and respect for and protection of minorities. Second, an economic criterion: candidate countries must have a functioning market economy and be able to cope with competitive pressure and market forces within the Union. Third is the criterion of being able to take on the obligations of EU membership, including adherence to the aims of political, economic and monetary union. This means candidate countries must adopt the entire body of EU law-known as the "acquis communautaire". The ultimate goal is bring peace and prosperity to member nations of EU.

The study evaluates the impact of the EU integration on achieving peace and prosperity by tracking the gains (or losses) made by each member nation on economic fronts for each of the 15 states of the union.

The data for this study is obtained from *Countrydata.com*. Seven economic variables are used to evaluate the impact of European integration on the participating nations.

The variables have been defined by *Countrydata.com* as follows:

- Current Account as Percentage of GDP: Estimated balance on the current account of the balance of payments, converted into US dollars at the average exchange rate for the year, expressed as a percentage of GDP, converted into US dollars at the average rate of exchange for the period covered.
- Current Account as Percentage of XGS: Estimated balance on the current account of the balance of payments, converted to US$ at average rate, expressed as a percentage of total exports of goods and services (XGS), converted into US$ at exchange rate for period covered.
- GDP per Head of Population: Gross domestic product per head of population, converted into US dollars at the average exchange rate for that year.
- Inflation: Estimated annual inflation rate, expressed as the weighted average of the Consumer Price Index and calculated as a percentage change.
- International Liquidity: Estimated annual net liquidity expressed as months of cover and calculated as the official reserves of the individual countries, including their official gold reserves calculated at current free market prices, but excluding the use of IMF credits and the foreign liabilities of the monetary authorities.

- Real GDP Growth: Annual change in estimated Gross Domestic Product, at a constant 1990 prices (for data in the 1990s), of a given country is expressed as a percentage increase or decrease.
- Exchange Rate Stability: It is measured by the annual percentage change in the exchange rate of the national currency against the US dollar (against the euro in the case of the US).

SUMMARY AND CONCLUSIONS

Using data envelopment analysis approach, this study compares the relative performance of EU 15 nations against one another with seven economic variables as the benchmark parameters from 1993 to 2006. Economic integration is a mechanism through which a group of countries try to improve their level of welfare through higher growth. A single market arrangement, the highest form of regional cooperation (as adopted by the European Union), requires that all residents (producers and consumers) should be governed by exactly the same rules. The guiding principle behind economic integration/economic union is the concept of convergence in per capita income and/or per worker income among participating nations. European Union was created with this basic principle in mind. By making conditions equal across Europe, EU will be able to bridge the gap between the rich and poorer nations. Over the last twelve years, EU has tried to create equal opportunities for the poorer nations and we try to find out if it helped poorer nations get richer and closer to rich nations in terms of GDP per capita as well as in terms of absolute amount of GDP. This study evaluates if EU delivered growth to member nations by creating equal conditions in terms of lower inflation through monetary policy coordination and lower budgetary deficits, and lower currency volatility through single currency. By studying the time period from 1993 to 2006, we also look at the variations in the performance of individual EU nations over a period of time under the European Union. This study finds that there is lack of convergence in the performance of EU 15 nations and some nations have performed more efficiently in contrast to other nations. The study also shows the areas in which inefficient member nations are lagging behind and how they can improve their performance to bring them at par with other participating nations.

The data envelopment analysis is a powerful technique for performance measurement. The major strength of DEA is its objectivity. DEA identifies efficiency ratings based on numeric data as opposed to subjective human judgment and opinion. In addition, DEA can handle multiple input and outputs measured in different units. Also, unlike statistical methods of performance analysis, DEA is non-parametric, and does not assume a functional form relating inputs and outputs. This study finds that there is lack of convergence in the performance of EU 15 nations and some nations have performed more efficiently in contrast to other nations.

However, as with any other study, this study using DEA has certain limitations (Ramanathan, 2003). The application of DEA involves solving a separate linear program for each DMU. Thus, the use of DEA can be computationally intensive. In addition, as DMU is an extreme point technique, errors in measurement can cause significant problems. DEA efficiencies are very sensitive to even small errors, thus making sensitivity analysis an important component of post-DEA procedure. Also, as DEA is a non-parametric technique, statistical hypothesis tests are difficult to apply. Therefore, further extension of this study would be to perform principal component analysis of the all the DEA model combinations. Furthermore, we can also use logistic regression to test the validity of the results.

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governed by exactly the same rules. The guiding principle behind economic integration/economic union is the concept of convergence in per capita income and/or per worker income among participating nations. European Union was created with this basic principle in mind. By making conditions equal across Europe, EU will be able to bridge the gap between the rich and poorer nations. Over the last twelve years, EU has tried to create equal opportunities for the poorer nations and we try to find out if it helped poorer nations get richer and closer to rich nations in terms of GDP per capita as well as in terms of absolute amount of GDP. This study evaluates if EU delivered growth to member nations by creating equal conditions in terms of lower inflation through monetary policy coordination and lower budgetary deficits, and lower currency volatility through single currency. This study finds that there is lack of convergence in the performance of EU 15 nations and some nations have performed more efficiently in contrast to other nations. Our study shows that at the beginning of the economic integration, eight out of fifteen member nations showed 100 percent efficiency in 1993. European Union made good progress towards convergence of economic performance, because in 1998 thirteen out of fifteen member nations show 100 percent efficiency. In recent years, EU has started lagging behind, because in January 2006, only four nations are 100 percent efficient, while all other nations are lagging behind in economic performance.

We used data envelopment analysis in this paper for performance measurement. The major strength of DEA is its objectivity. DEA identifies efficiency ratings based on numeric data as opposed to subjective human judgment and opinion. In addition, DEA can handle multiple input and outputs measured in different units. Also, unlike statistical methods of performance analysis, DEA is non-parametric, and does not assume a functional form relating inputs and outputs.

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Available upon request.

SCORE MONITORING SYSTEMS

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ABSTRACT

Credit plays a significant role in today's economy. Economic globalization and emerging new technology is making it easier for customers to choose among credit products. The credit industry is becoming more and more competitive. Decision analysts in this industry must be innovative and unique with their ideas. They want to balance gains from credit approval with risk of losses. All the big companies invest a lot of resource to develop effective analytical methods. A common tool analysts use to support business decisions is a scoring model. Scores are used to rank order customers. We need to monitor scores periodically for performance.

BACKGROUND

At Chase Card Services, the analytical teams have developed various scores to target customers for different campaigns. If we are successful in targeting the most profitable customers, it will generate significant profit and minimize marketing costs. All scores, however, degenerate. We need precise and timely monitoring to detect performance drops. We have built a general-purpose score monitoring system to monitor these scores. We use characteristic analysis and population information as reporting tools and statistical tools such as the Komolgorov-Smirnov statistic as performance measure.

SCORING MODEL

A scoring model is an objective mathematical tool that assigns score values to each customer based on their characteristics. These scores reflect the comparative likelihood of an event of interest. For example, a score can show if a customer is more or less likely to have a certain amount of balance on their credit card. In the credit card industry, scores are used to gain valuable insight regarding customers' risk, response to products, loans, attrition, retention, etc.

Modeling Methodologies

Logistic Regression is one of the most common methods to build scores in the credit card industry. The main assumption in a Logistic Regression model is that there is a linear relationship between the independent variables and the natural log of the odds of the dependent variable [3].

$Ln\left[\frac{p}{(1-p)}\right] = \beta_0 + \beta_1 * X_1 + \cdots + \beta_n * X_n$, where p is the probability that the dependent variable, Y=1. [1]

In Linear Regression, however, the assumption is that there is a linear relationship between the independent variables and the dependent variable.

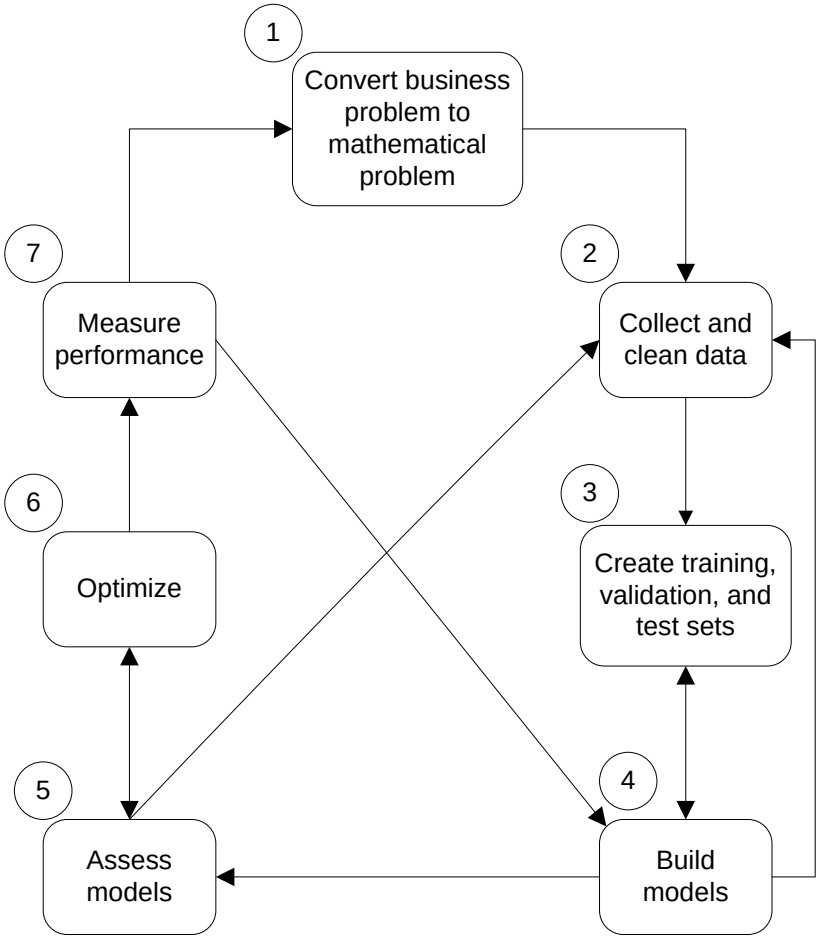
$$Y = \beta_0 + \beta_1 * X_1 + \cdots + \beta_n * X_n$$

We can also build scores based on Decision Trees, Genetic Algorithms, etc., but Logistic Regression models prove to be the most stable ones.

Data Mining Methodologies

Any statistical modeling starts by understanding the business problem and gathering data. In the financial industry, a lot of times there is an abundance of data. The challenge is to find data that is most relevant and useful. The following figure illustrates some of the core data mining practices.

Figure1: Data mining steps



Any modeling project would require significant proportion of time spent to gather and clean data. Once a modeler understands the variables and does some pre-selection, the data is ready to be used to build models. After we have built a model, we must assess the correctness of it and do optimization (depending on application of the particular model). The last step is to measure performance on test data. A data mining process is not strictly sequential – there is always going back and forth between steps. A modeler will frequently find himself/herself going back to get some more data or rebuild models [2].

PERFORMANCE TRACKING

Some objectives of performance tracking are:

1. Minimize operational risk by taking immediate actions
2. Detect unusual behaviors early, and incorporate corrections into business rules
3. Evaluate model performance over time
4. Make decisions regarding rebuilding or refitting current model

Performance data generally contain accounts or customers who responded to offers, or got accepted for loan, credit card, etc[1]. The eligible customers are divided into groups (deciles or twentiles) based on their scores. When we compare performance data by these same groups, we get the success rates in each group. More performance analysis is done after the group-level response rates are determined.
It is important to understand the business problem while doing performance analysis. Analysis of a binary target variable is very different from an interval target variable.

Tools

Some popular tools to measure performance are Komolgorov-Smirnov (KS) Statistic, C Statistic, Hosmer-Lemeshow Statistic, etc.

This section will give a brief description of the KS statistic and how it is used to implement the balance transfer score monitoring system.

KS is a separation statistic. It is the maximum difference between two curves. Given responder and non-responder distributions, the KS tells us where the two curves have maximum separation. This separation indicates how well the system is performing. If the model is performing very well, the good and bad distributions will lay side by side. If the model is performing poorly, the distributions will not be distinguishable. A large KS value means that many non-responders are found among the low scores and relatively more responses are found among the high scores [3].

Example

Consider a scoring model to predict sales of some product. After using the score, we acquire performance data. A “good” customer is one who makes a purchase of the particular product. We have fifty thousand customers whom we divide into 10 groups of five thousand each. A total of 2131 customers made a purchase. Table 1 shows the calculation of KS.

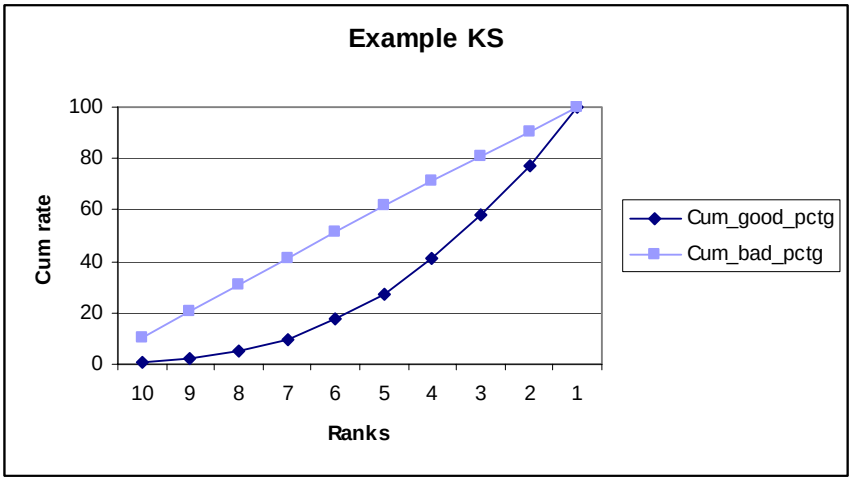
Table 1: KS calculation table

Ranks	Good	Bad	Good Rate	Cum Good	Cum Bad	Cum good pctg	Cum bad pctg	Separation
10	16	4984	0.32	16	4984	0.750821211	10.41174873	9.66092752
9	35	4965	0.7	51	9949	2.393242609	20.7838058	18.39056319
8	52	4948	1.04	103	14897	4.833411544	31.12034929	26.28693774
7	96	4904	1.92	199	19801	9.338338808	41.36497524	32.02663644
6	174	4826	3.48	373	24627	17.50351947	51.4466565	33.94313703
5	214	4786	4.28	587	29413	27.54575317	61.44477637	33.8990232
4	289	4711	5.78	876	34124	41.10746129	71.28621864	30.17875735
3	362	4638	7.24	1238	38762	58.09479118	80.97516138	22.8803702
2	401	4599	8.02	1639	43361	76.91224777	90.58263177	13.67038399
1	492	4508	9.84	2131	47869	100	100	0

[1] Type of performance data will vary depending on the objective of the scoring model

The groups are given ranks from 1 to 10, 1 being the most likely buyer and 10 being the least likely buyer. To calculate KS, we first compute the cumulative good and bad percentages. The KS is the maximum difference between the two. We can see that the score has a KS of 33.94. [2]
Figure 2 shows the separation between cumulative good and bad percentages.

Figure 2: Separation between cumulative good and bad percentages



In figure 2, the further apart these two lines are, the better this scoring model is performing.

MONITORING REPORTS

Monitoring reports can be divided into two main groups:

1. Front-end Reports
2. Back-end Reports

Front-end Reports

Front-end reports are created soon after the creation of scores and distributions. The most important objectives of these reports are to monitor score distributions and detect errors before launching campaigns or granting loans. We are creating Characteristics Analysis Report and Population Stability Report as front-end reports. Characteristics Analysis Reports usually show the mean and median scores, percentage of population, score range, score differences compared to the past for each group. Population Stability Reports deal with score distributions at different times. These reports help us to monitor changes in the score distributions over time. Approval Rate Report, Override Rate Reports are also used as front-end reports in the industry [3].

Back-end Reports

We create the back-end reports are after we have evaluated the response (or any outcome of interest). The primary reason to make these reports is to track performance and detect

[2] The data used here is fictitious.

operational errors. KS statistic report is widely used in the industry as back-end report. The KS value indicates how good the scoring model is in separating the good[3] customers from the bad ones. If we see a steady decline in KS, we should do proper investigations on the model and consider rebuilding the score.

CONCLUSION

The impact of a scoring model on business is immense. By targeting more responsive customers, we can increase profit and lower cost significantly. Because response rates in credit products are low, difference of a percentage point can make a huge difference in earnings. Therefore, it is very important to build robust scoring models and track them carefully.

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[3] "Good" customers may be more profitable, or less risky, or more responsive, or all of these depending on application of the model.

SOLVING LINEAR SYSTEM OF INEQUALITIES WITH APPLICATION TO LINEAR PROGRAMS

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ABSTRACT

In this paper we present an improved Algebraic Method to solve linear systems of inequalities with applications to linear optimization. The proposed method eliminates the need to manipulate linear inequalities to introduce additional variables. We present application of the proposed method to handle linear optimization with varying objective function. Numerical examples are provided to illustrate the concepts presented in the paper.

INTRODUCTION

There are numerous algorithms for solving systems of simultaneous linear equations with unrestricted variables in linear algebra. However, the problem of solving a system of simultaneous linear inequalities in which some variables must be non-negative is much harder and had to wait until the linear programming (LP) era for a resolution.

The Graphical Method of solving LP problems provides a clear illustration of the feasible and non-feasible regions, as well as, vertices. Having a visual understanding of the problem helps practitioners with a more rational thought process. For example, the fact that the optimal solution of a linear program with a non-empty bounded feasible region always occurs at a vertex of the feasible region. However, the Graphical Method is limited in its applicability to solving LP problems having at most two decision variables and its appeal of human vision is restricted when there are many constraints present.

The ordinary algebraic method is a complete enumerating algorithm to solve linear programs (LP) with bounded solutions. It converts all inequality constraints to equality constraints to obtain a system of equations by introducing slack/surplus variables, converts all non-restricted (in sign) variables to restricted ones by substituting the difference of two new variables, and finally solves all of its square subsystems of equations. This conversion of an LP into a pure algebraic version overlooks the original space of the decision variables and treats all variables alike throughout the process.

In this paper, we propose an improved method to overcome these deficiencies. The Algebraic Method is designed to extend the graphical method results to a multi-dimensional LP problem. The proposed method uses *Analytical Geometry* concepts and overcomes the limitation of human vision of the Graphical Method. The algorithm initially concentrates on locating basic solutions by solving selected squared subsystems of equations of size dependent on the number of decision variables and constraints. Then, a feasibility test is performed on the obtained solution to be retained for further considerations.

THE LINEAR PROGRAMMING PROBLEM

Linear Programming is a problem-solving approach developed to help managers make decisions. Numerous applications of linear programming can be found in today's competitive business environment. Consider the following standard LP formulation

Problem P: Max (or Min) $f(X) = CX$

Subject to $AX \leq a$,
$BX \geq b$,
$DX = d$,
$X_i \geq 0$, $i = 1, \ldots, j$
$X_i \leq 0$, $i = j+1, \ldots, k$
X_i unrestricted in sign, $i = k+1, \ldots, n$

where matrices A, B, and D have n columns with p, r, and q rows respectively and vectors C, a, b, and d have appropriate dimensions. Therefore, there are $m = (p + r + q)$ constraints and n decision variables. It is assumed that $m \geq n$ in Problem P. Note that the main constraints have been separated into three subgroups. Without loss of generality we assume all RHS elements, a, b, and d, are non-negative. We do not deal with trivial cases where $A = B = D = 0$ (no constraints), or $a = b = d = 0$ (all boundaries pass through the origin point).

SOLVING A SYSTEM OF LINEAR INEQUALITIES

Generally speaking, the Simplex method for linear programming is strictly based on the theory and solution of system of linear inequalities. The basic solutions to a linear program are the solutions to the systems of equations consisting of constraints at binding position. Not all basic solutions satisfy all the problem constraints. Those that do meet all the constraint restrictions are called the basic feasible solutions. The basic feasible solutions correspond precisely to the vertices of the feasible region.

Definition 1: A solution to any system of equations is called a Basic Solution (BS). Those Basic Solutions which are feasible are called Basic Feasible Solutions (BFS).

The optimal solution of a bounded LP always occurs at a BFS, i.e., one of the vertices of the feasible region. The importance of this result is that it reduces the LP problem to a "combinatorial" problem that of determining which constraints out of many should be satisfied by the optimal solution. The algebraic simplex method keeps trying different combinations and computes the objective function for each trial until the best value is found.

The Ordinary Algebraic Method

Assuming the Problem P has a bounded solution; then the usual algebraic simplex method proceeds as follows:

1. Convert all inequality constraints into equalities by introducing slack/surplus variables.

2. Convert all non-restricted variables to restricted ones by substituting the difference of two new variables (this step is not necessary; however, for uniformity in feasibility testing, this conversion is always performed).
3. Calculate the difference between the number of variables and the number of equations and set that many variables to zero.
4. Determine the solution to all these systems of equations. Set up the basic solution (BS) table to find out which BS is feasible (not violating the non-negativity condition of slack/surplus).
5. Evaluate the objective function for each BFS and find the optimal solution with best value.

The algebraic method is hard to apply because of the number of systems of equations involved:

$$\frac{(\#\text{ of var.} + \#\text{ of ineqs.})!}{(\#\text{ of consts.})!(\#\text{ of vars.} - \#\text{ of equal. consts.})!}$$

$$= \frac{(2n - j + p + r)!}{(p + r + q)!(2n - j - q)!}$$

Each system of equations contains (p + r + q) constraints with (p + r + q) variables which include slacks/surplus and the additional variables introduced for the unrestricted and negative variables.

The Improved Algebraic Method

Now we present an improved Algebraic Method of solving a system of linear inequalities (SLI) that does not require the formulation of an auxiliary LP problem and LP solution algorithms such as Simplex. We provide a simple methodology to extend the solution of SLI of one or two dimensions to systems of higher dimensions. We are interested in finding the vertices of the feasible region of Problem P, expressed as system of linear equalities and inequalities:

$$AX \leq a,$$
$$BX \geq b,$$
$$DX = d,$$

where some $X_i \geq 0$, some $X_i \leq 0$, and some X_i unrestricted in sign. Matrices A, B, and D as well as vectors a, b, and d have appropriate dimensions. The interior of the feasible region is defined by the full set of the vertices obtained. Other relevant domains, such as faces, edges, etc. of the feasible region are defined by appropriate subsets of these vertices. This is the basis of the proposed Algebraic Method. We present the following steps to identify all such subsets of vertices using a constraint-vertex table.

Step 1. Convert all inequalities into equalities.
Step 2. Calculate the difference between the number of equations and the number of variables (assuming $m \geq n$) and set that many variables to zero.
Step 3. Determine BS to this system of equations. Go back to Step 2 if any BS is left.
Step 4. Check feasibility of all solutions obtained in Step 3 to determine BFSs.

The coordinates of vertices are the BFSs of the systems of equations obtained by setting some of the constraints at binding (i.e., equality) position. For a bounded feasible region, the number of vertices is at most combinatorial C_n^m where m is the number of constraints and n is the number of variables. Therefore, a BS is obtained by taking any set of n equations and solving them simultaneously. By plugging this BS in the constraints of other equations, one can check for feasibility of the BS. If it is feasible, then this solution is a BFS that provides the coordinates of a corner point of the feasible region.

NUMERICAL EXAMPLES

We provide an example to explain the proposed Algebraic Method and develop parametric representation of the feasible region for the given system of linear inequalities (SLI).

Example 1: Suppose we wish to solve the following SLI to find the vertices of its feasible region:

$$\begin{aligned} -3X_1 + X_2 &\leq 6 \\ X_1 + 2X_2 &\leq 4 \\ X_2 &\geq -3 \end{aligned}$$

Step 1: Consider all of the constraints at binding position, i.e., all with equality (=) sign. This produces the following 3 equations in 2 unknowns:

$$\begin{aligned} -3X_1 + X_2 &= 6 \\ X_1 + 2X_2 &= 4 \\ X_2 &= -3 \end{aligned}$$

Steps 2-4: Here we have m = 3 equations with n = 2 unknowns. So there are at most 3 basic solutions. Solving the three resultant systems of equations, we have:

X_1	X_2	Feasible?
-3	-3	Yes
10	-3	Yes
-8/7	18/7	Yes

The solutions in the above table are all BFSs. Therefore, the vertices of the feasible region are:

$X_1 = -3$ $X_2 = -3$ $X_1 = 10$ $X_2 = -3$ $X_1 = -8/7$ $X_2 = 18/7$

We extend this example to present a parametric representation of the feasible region of an SLI. Using the parameters λ_1, λ_2, and λ_3 for the first, second and third vertex, respectively, we get:

$$X_1 = -3\lambda_1 + 10\lambda_2 - 8/7\lambda_3$$
$$X_2 = -3\lambda_1 - 3\lambda_2 + 18/7\lambda_3$$

for all parameters λ_1, λ_2, and λ_3 such that $\lambda_1, \lambda_2, \lambda_3 \geq 0$, and $(\lambda_1 + \lambda_2 + \lambda_3) = 1$. This representation is also known as the Convex Hull of the feasible region. By substituting suitable values for these λ values in the convex hull, one can generate any point of the feasible region.

APPLICATIONS TO LINEAR PROGRAMS

The proposed Algebraic Method can be used to solve linear programs as illustrated below. The following example is a continuation of Example 1.

Example 2: The following LP is from Hillier and Lieberman [1, page 147].

$$\begin{aligned} \text{Max} \quad & -X_1 + 4X_2 \\ \text{subject to:} \quad & -3X_1 + X_2 \leq 6 \\ & X_1 + 2X_2 \leq 4 \\ & X_2 \geq -3 \\ & X_1 \text{ , } X_2 \quad \text{unrestricted in sign} \end{aligned}$$

As determined earlier, the parametric representation of the feasible region is:

$$X_1 = -3\lambda_1 + 10\lambda_2 - 8/7\lambda_3$$
$$X_2 = -3\lambda_1 - 3\lambda_2 + 18/7\lambda_3$$

Substituting the parametric version of the feasible region into the objective function, we obtain:

$$f(\lambda) = -X_1 + 4X_2 = -9\lambda_1 - 22\lambda_2 + 80/7\lambda_3, \qquad (1)$$

over the closed domain $\lambda_1, \lambda_2, \lambda_3 \geq 0$, and $(\lambda_1 + \lambda_2 + \lambda_3) = 1$. This is a convex combination of three points on the real line R_1; namely the coefficients -9, -22, and 80/7. Clearly, the optimal solution occurs when $\lambda_3 = 1$ and all other λ's are set to 0, with maximum value of 80/7 at $X_1 = -8/7$, $X_2 = 18/7$. Note that the optimal solution is one of the vertices.

Proposition: The maximum (minimum) points of an LP with a bounded feasible region correspond to the maximization (minimization) of the parametric objective function $f(\lambda)$.

Let the terms with the largest (smallest) coefficients in $f(\lambda)$ be denoted by λ_L and λ_S

respectively. Since f (λ) is a (linear) convex combination of its coefficients, the optimal solution of f (λ) is obtained by setting L or S equal to 1 and all other $\lambda_i = 0$. The maximum and minimum points of an LP with a bounded feasible region correspond to $\lambda_L = 1$ and $\lambda_S = 1$, respectively.

More on the Objective Function

The parametric representation of the objective function provides a wealth of information. It can be easily seen that if the objective in the two examples presented above is changed to Min (instead of Max); a practitioner does not have to entirely resolve the problem. A look at the parametric representation f(λ) in equation (1) reveals that the minimum value of the objective function ($-X_1 + 4X_2$) is -22 when $\lambda_2 = 1$, representing the feasible point ($X_1 = 10$, $X_2 = -3$). Therefore, one can deduce that the value of the function ($-X_1 + 4X_2$) range from a low of -22 (the minimum value) to 80/7 (the maximum value).

The parametric representation of the feasible region of an SLI is useful in solving the corresponding LP with varying objective. For any given objective function, one can easily obtain a parametric representation, f(λ), of the objective function to determine optimum value of the objective function, whether maximum or minimum. Further, bounds on the range of the objective function value can be obtained.

CONCLUSIONS

In this paper we present a new direct method of solving a linear system of inequalities (SLI) that does not require the formulation of an auxiliary LP problem and LP solution algorithms such as simplex. We provide a simple methodology to extend the solution of SLI of two dimensions to systems of higher dimensions. The proposed method can be used to optimize LP problems with varying objective function. Given a system of linear equalities and/or inequalities, the method provides all vertices of the feasible region. A parametric representation of the feasible region as a convex combination of the vertices is developed. This parametric representation of the feasible region enables a practitioner to solve linear optimization problems with varying objectives.

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ELECTRONIC COMMERCE and OPERATIONS RESEARCH: A SURVEY

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ABSTRACT

Today, e-commerce is analogous to the invention of the press or the industrial revolution. While improving very quickly, e-commerce also creates many promising opportunities for Operations Research (OR). In this study, starting with the definition of e-commerce, the question of "what are the OR applications in e-commerce" is answered followed by a literature review on the main issues of e-commerce where OR practitioners are mostly active. Some real world examples in different application areas of e-commerce are analyzed and further directions on the topic are proposed.
Keywords: Operations Research, Electronic Commerce, Internet, Supply Chain Management

1. INTRODUCTION

The rapid improvements in information and communication technologies during the last quarter of the 20th century lead to a multidimensional transformation in economic, social and political directions. At the same time, with the globalization, a scientific and technological revolution has started, affecting the whole system drastically. Those have caused to differentiate all forms of economic relationships. In this period, Information Technologies sector, in other words, "the new economy", has brought about the swift improvement process of electronic commerce (e-commerce). Today, e-commerce is analogous to the invention of the press or the industrial revolution. It is a common belief that the effects of the e-commerce revolution in the globe will be greater than expected.

While improving very quickly, e-commerce also creates different promising opportunities for Operations Research (OR). The advent of World Wide Web, and relatively of e-commerce, changes this traditional situation significantly. Today, there are new classes of OR-utilizes, i.e. individuals using the Web. This new class leads to a set of OR applications being greater than before potentially and, has non-traditional format [9].

In this study, starting with the definition of e-commerce, first the question of "what are the OR applications in e-commerce" will be answered. Then, the results of literature review on the issues in which areas of e-commerce OR practitioners are mostly active and how they are benefited from it will be discussed. Related real-world examples will also be included. Finally, further directions on this topic will be proposed.

2. GENERAL INFORMATION ABOUT E-COMMERCE

Since this article is about OR applications in e-commerce, it will be useful to include a short review about the e-commerce terminology before going into the details of OR applications. This section is going to give basic descriptions and explanations about e-commerce.

Internet applications consist of three main classes: dynamic web sites, static web sites, and e-commerce. There is a growing interest in the use of electronic commerce as a means to perform business transactions [16]. E-commerce can be defined from many different perspectives:

- From a *communications perspective*, e-commerce is the delivery of information, products/services, or payments via telephone lines, computer networks, or any other means.
- From a *business process perspective*, e-commerce is the application of technology toward the automation of business transactions and workflow.
- From a *service perspective*, e-commerce is a tool that addresses the desire of firms, consumers, and management to cut service costs while improving the quality of goods and increasing the speed of service delivery.
- From an *online perspective*, e-commerce provides the capability of buying and selling products and information on the Internet and other online services [16].

E-commerce encompasses all commercial operations based on processing, carrying, and saving information in different forms of individuals and societies in open (Internet) or closed network areas (Intranet), which can be reached by limited users, and it aims at creating a value [3]. E-commerce is composed of three main categories (Table 1), (1) consumer-oriented activity, (2) business-oriented activity and (3) government oriented activity. Both classes are supported by e-commerce network infrastructure implying with network infrastructure, network applications, and decision technologies.

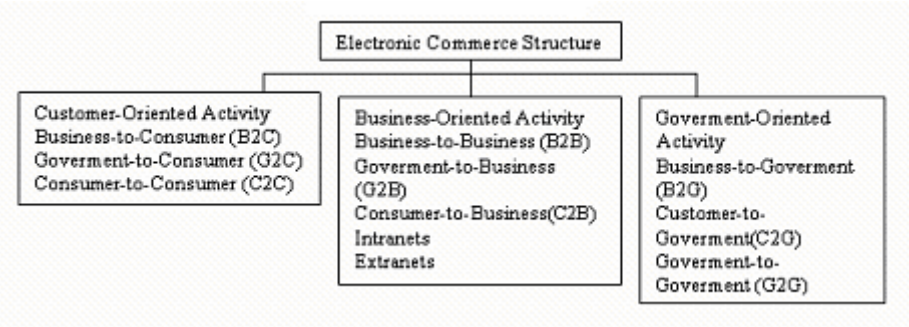

Figure 1: E-Commerce Structure

A transaction that occurs between a company and a consumer is called a B2C transaction. The term may also describe a company that provides goods or services for consumers. Amazon and Dell are examples of Business to Consumer on the web. Government-to-Consumer is the online non-commercial interaction between local and central Government and private individuals. For instance, Government sectors become

visibly open to the public domain via a Web Portal, thus making public services and information accessible to all. On the other hand, a transaction that occurs between consumers is called a C2C transaction. Consumers sell directly to each other by electronic classified advertisements on auction sites. eBay is an example of consumer to consumer on the web [6].

A transaction that occurs between a company and another company is called a B2B transaction. The term may also describe a company that provides goods or services for another company. GM and Ford are examples of Business to Business on the web. Government-to-Business is the online non-commercial interaction between local and central government and the commercial business sector. For instance, http://www.dti.gov.uk is a Government web site where businesses can get information and advice on e-business 'best practice'. C2B (consumer to business) is a business model where the consumer creates the products for a company that they will also buy [11].

Intra-Business (Intranets) is a network architecture designed to serve internal informational needs of a company using Web concepts and tools. It provides:

- Internet capabilities
- Search engines
- Tools for communication and collaboration (Organizations use intranets for a variety of internal, often operational, accessing customer records and internal reports, conducting administrative procedures, collaborating, distributing corporate information, providing personnel services, training, and automating work flows)
- A relatively low-cost conversion of an existing network system to internal Web.
- Fairly safe within company firewalls
    - *Employees can get out on the Web easily*
    - *Outsiders cannot get into the intranet*
- Change in organizational structures and procedures and help reengineer corporations

Connection of two or more intranets via internet is called extranet. An extranet share only enough information with connected intranets [8].

Business-to-government e-commerce (B2G) networks allow businesses to bid on government RFPs in a reverse auction fashion. A transaction occurs between a customer and the government such as tax compliance (Wikipedia).

E-commerce has advantages and disadvantages. These pros and cons are discussed in the literature very extensively. The main advantages of e-commerce are:

- Worldwide availability.
- Simplification of communication.
- Reduction of paperwork and reduction of errors / time / overhead.
- Ease of entering a new geographical region, handling new business opportunities, streamlining and automation of purchasing [17].
- Streamlining buyer-to-seller relationship resulting from simplified communication and direct interaction.

- Improvement of market analysis.
- Reduction in sales and marketing cost and lower information & communication cost
- Being able to serve at all times of the day, every day of the week, every week of the year, in every time zone, around the world [4].
- Reduction in the cost of creating, processing, distributing, and storing of services and products.
- Reduction of the cost of communication.
- Fast delivery for digitized products such as drawings, documents and software.
- Increase in the reputation of the company [19].

Disadvantages of e-commerce are:

- Lack of system security, reliability and standards.
- Lack of privacy.
- Insufficient bandwidth; some transactions are still rather slow [7].

E commerce is a new field, based on several different disciplines, which are mutually interrelated. For instance, economists are needed to understand the myriad of marketplace and financial considerations that shape the business environment. Social scientists are needed to understand the behaviors of consumers and organizational entities competing in the new economy. Computer scientists and information technology specialists are needed to understand the electronic and informational linkages among the infrastructures. Linguistics, as a science, is necessary to take into account the interdisciplinary nature of e-commerce and find appropriate solutions for rather complex terminology, which requires continuous updating and unambiguous identification of entities. In brief, e-commerce has relationship with business, law, linguistics, international relations, politics, anthropology, sociology, organization theory, process and software engineering, database, networking, security, operations research, etc. In this study we focus on operations research application in e-commerce.

3. OPERATIONS RESEARCH APPLICATIONS IN E-COMMERCE

The reasons of e-commerce's needs for OR can be summarized as follows:

a. Complex situations could occur at any moment of design, planning, and processing. OR offers an analytical approach. If analysis means breaking into pieces - a complex problem; OR can cope with the complexity created by e-commerce.

b. Risk and uncertainty: Since technological improvements happen very rapidly, past is not a good guide for today's world. OR could deal with the risk and uncertainty by using statistics, decision analysis, and probability models.

c. Reliability: One of the main characteristics of e-commerce is that it should be understood profoundly. OR is a reliable tool for most business subjects having such a characteristic.

d. Speed and automation: Since e-commerce uses not only information technology but also decision technology; OR provides a decision that has a quick, repeatable, and automatic structure. Clearly, e-commerce means automating business processes and bringing together with the other companies by Internet interface.

This study addresses three issues of e-commerce in which OR is mostly active [10]:

(1) Information Goods and Services (B2C and B2B)-especially in online financial and travel- related services.

(2) Physical Goods and Services (B2C and B2B)-especially in Supply Chain Management (SCM) and electronic markets (e-markets).

(3) E-business Network Infrastructure and Its Applications-especially in network design and quality-of- service (QoS) improvement.

In other words, many areas taking part in e-commerce are the application areas that use OR techniques inside themselves. Main application areas can be summarized as online auctions and e-market's design, Customer Relationship Management (CRM), data mining, search engines, dynamic pricing and yield management, individualization and suggestion technologies, modeling of QoS for network infrastructure, and SCM.

3.1. OR Applications in Information Goods and Services

Information goods include books, greeting cards, music, software, video games, and videotapes. Although these goods are traditionally manufactured and delivered in physical form, they can be digitized so that customers receive them digitally such as a solid state player to display books, a screen to display an electronic greeting card., etc. The main categories of *information services* are entertainment, financial, news, telecommunications, and travel, but only to the extent that their delivery and business processes are digital.

Packaged software provide a familiar context for OR to add value. For instance, incorporating OR into geographic information system (GIS) software can yield large practical benefits. Leading GIS software vendors, such as ESRI, now offer Internet map servers and OR components that can serve as platforms for OR applications. For instance, with real-time data about truck locations and traffic, GIS and OR already helps retailers achieve greater efficiencies in product delivery.

3.1.1. OR Applications in Financial Services

The work by the Management Science Group at Merrill Lynch Private Client Group shows significant evidence that OR has had an active role in financial applications for a long time. The group had done analysis on a strategic service-pricing response to the discount online broker challenge which shows many OR based companies are actually producing such applications.

An example for online financial advisor company is the Optimal Retirement Planner site. This site, via today's investments, planned dues, and desired yield, formulizes a model with Linear Programming and calculates the money that has the optimal value combined with the taxes suitable in the period of retirement. Another application example is the site which is named Financial Engines Investment Advisor. In this site, Monte Carlo Simulation and Quadratic Programming are applied for probable investment results and portfolio optimization respectively.

3.1.2. OR Applications in Travel-Related Services

Before illustrating the examples, it should be emphasized on this topic that information services related to travel, especially travel agencies, are reviewed. “Direct sales” topic is one of the subtopics in physical services.

Airline sector could be considered as the leader in e-commerce principles before Internet improvement. B2B electronic information transfer firstly happened in this sector. Consequently, huge application opportunities have occurred for OR practitioners. Reservation system with computer can be considered as one of the first examples in e-commerce. This system improved by Sabre, Inc. and its extensions have become the basis of today’s global reservation system.

Airlines use OR techniques for demand estimation and revenue optimization, design of sales promotion, determination of cross sales like rental car, hotel, etc. [13]. If it is examined in detailed manner, it can be seen that the role of decision support systems in travel-related services is important. The success of the communication, data, and control directly depends on the decision support systems. The whole system which connects the consumer to the airline via a website needs to be supported via such a system so that the website will be able to provide the user necessary information and service.

Another application area in e-commerce that has been very frequently encountered during this survey is the yield management, which is based on the aim of gaining maximum income when there is a limited capacity in an airplane. As getting near to the arrival time for a plane, there occurs a dilemma between decreasing the general ticket price and rising up the prices for irreparable travelers having no more chance. For such a situation, dynamic pricing is a powerful technique. The answers of the questions “when and how much decrease or increase” can be modeled and answered using in OR techniques. The process which aims to determine the time and amount needs to use some information in order to update the prices when necessary. E-commerce takes place at this point. It connects the customer to the airline, the customer demands a seat in the place, the price is updated by a dynamic pricing technique and then the customer receives the information about the availability and the price of the seat he requested.

3.2. OR Applications in Physical Goods and Services

Traditionally, supply chain has been considered as a model that starts with raw material and delivers finished good to the customer. Today, supply chains have more dynamic structure than the past. With the high-speed communication by Internet, companies apart from distributors have two new opportunities for selling their goods or services through Internet. Those are sales of their own products by using company’s own Web site, i.e. direct sales, and through e-markets in which customers and sellers come together on the Net and the transaction costs decrease. In e-markets, products from different dealers are gathered and offered to the customers. According to Forrester Research, in 2004, 53 percent of the B2B e-commerce will occur through e-markets. Among the sectors uses e-commerce are automotive, hard industry, electronic, and energy. With this new structure, there is not only a horizontal relationship between customers and dealers but also a necessity for dealers (or customers) to act together

[12]. For direct sales and e-markets, Prentice Hall and Amazon web sites can be given as examples respectively.

OR techniques find themselves different application areas by using real-time information on supply and demand. In general, companies use OR tools in sales, CRM, and advertising. Each potential customer visiting a web site offering a product or service should decide on whether to purchase or not and what he/she will purchase from the site. In this decision stage, Multi Criteria Decision Models are used to help customers' decisions. Similarly, it is confronted with the models in the framework of customer service management. Those models are developed to help purchasing decisions using OR tools. The models, which provide complementary goods and services showing on the screen at the right time, are mainly formed by following customer's Internet service server and collecting that information in a database. Furthermore, special algorithm that has been developed to answer customer's expectations and complaints quickly and accurately are used [21].

To give more specific examples, OptiBid site could be mentioned. This online auction site uses an Integer Programming multi-attributive system. With this programming technique, the site is used by dozens of transportation companies in order to choose transportation providers in e-markets. Trajecta, Inc. uses stochastic optimization models to help banks in the management of credit cards' portfolios. MarketSwitch is an advisor site that helps Internet advertisement networks and e-commerce sites to show the advertorials and promotions on the screen at the right time, as mentioned before. While doing this, Constrained Optimization is used [10].

On the purchasing in an online store site, Van den Poel and Buckinx conducted a study to predict whether or not a customer will purchase during his/her next visit to the website [22]. To achieve this, they included many predictor variables such as the number of clicks during the last visit, the total number of viewed pages concerning the procedures of the site, the number of times one made use of the search engine during the last visit and the average visit time. In the classification step, they used logit modeling, which is known to provide reliable results. Furnival and Wilson's branch and bound algorithm i.e. global score algorithm, was used in the variable selection step. This method provided the best subset of the purchase predictors.

For the decision-makers about supply chain, a framework was examined by Sarkis and Talluri [20]. This work mainly focuses on the decision process in "deciding which electronic commerce technology media and software is most suitable for the whole supply chain". For the factors such as internal adaptation, external adaptation, openness, and security; an Analytic Hierarchy Process (AHP) model is developed. Then, according to this model a goal programming model including software system, communication system, choice and compatibility constraints is established and solved.

3.2.1. Models and Algorithms Suggested For Online Auctions

Online auction is one of the most popular sale tools in e-commerce. Due to its calculation ability, Internet provides selling the same product in different units in one session. Although they do not have a long history, today online auctions are one of the most developing tools in e-commerce, by reaching 1 billion $ operation volume until now. Another attractive characteristic of these auctions is the variability in products.

Beam, et al. present a multi-unit auction site that uses Markov Chains and optimization by considering batch size and pricing [1].

Davenport and Kalagnanam suggest a complex integer programming model used in procurement of direct inputs in production process [5]. In their model, if direct inputs of a computer, like RAM, screen, keyboard, are purchased in a great number, dealers may reduce the sales price significantly. We could face different pricing strategies in e-commerce, as in the economy. When deciding on accepting the offers of dealers, the batch size taken from each dealer and reservation price could be given as the examples of decision maker's constraints. In this study, authors claim that although there are some business constraints, in the optimal design of an online auction site, another factor is its economic situation.

In the work of Pinker, et al., the writers suggest a combination of Bayes' analysis and Dynamic Programming for the problem of multi-unit auction site's design [18]. In each sequential auction's stage, since fewer products are offered, more revenue is gained. However, at the same time, each additional auction enhances fixed costs and inventory costs. In this complex design problem, it is confronted with two important design questions: (1) optimal product quantity offered in each period, and (2) optimal auction number. Some of the conclusions derived from this study are as follows: In case the batch size has an optimal solution, total profit is sensitive to total number of sessions. If the distribution of the offered values is known, through sequential auctions, optimal batch size increases monotonously.

In their study Wu and Jin examine different models including customers and dealers competing with each other in the market by assuming that together with e-commerce, the structure of supply chain has also been conceptually transformed [23]. Further, it is also assumed that the demand is a linear function of the price. For the market, there is also a third group, called electronic brokers (e-brokers), generally service servers, which conduct some commercial activities, especially shopping. In such auctions, the side starting the agreement and offering is called "Stackelberg Leader"; usually they are dealers or e-brokers. In this work, four different models are studied according to whether each side has entire information about the other side or not (asymmetric information). The following questions are answered, "how competition affects the customer in e-commerce", "whether there is better (optimal) solution for the dealer or not", and "how the broker company's role shaped in reaching optimal solution for both sides".

3.3. OR Applications in Network Infrastructure

The development of network infrastructure leads to the improvement of e-commerce applications. With the widespread usage of Internet, these applications have been focused on service quality.

In this study, Bhargava suggests that the future of OR in e-commerce is in having OR practitioners on TCP/IP-based networks [2]. Furthermore, it is claimed that, apart from applet and other server's technologies, Java applications will be the leader of network infrastructure. In this paper it is emphasized that Java technologies are more powerful than others. He also suggests that those technologies will supply plentiful opportunities for the developers and practitioners of OR/MS applications.

Looking from the customer's perspective, in re-designation of Local Access Networks in network infrastructure for e-commerce, queuing theory and new statistical

techniques different from the traditional Poisson models should be used to respond to different types of the calls [24]. Moreover, in order to minimize the response time of the service server, minimum cost, multi-unit flow algorithms are utilized.

4. CONLUSIONS AND FURTHER DIRECTIONS

An increasing number of the business processes today is managed through Internet. Therefore, the necessity of OR tools and its algorithms in this new era should not be overlooked. E-commerce itself will bring new opportunities differing from optimization models for OR practitioners. This necessity will be observed in diverse areas of e-commerce, such as SCM, manufacturing, customer service, e-tailor system design, pricing, advertising, internet congestion control, and more [14]. In the future, it is expected that the demand for OR techniques will rise up. OR practitioners, in order to respond to this demand and to take action in this field, should comprehend e-commerce processes and follow progress in information technologies.

It is expected that there will be dozens of application areas for OR applicants in the near future. For instance, the concept of "extension period" will be one of these areas. Now, it is observed that if there is no order in the last 5 minutes of the online auction, the closed time of the auction is extended to additional 5 minutes, while in some sites this period can only be 1 minute [15]. For further study, in order to determine optimal extension period of time in online auctions instead of the trial-and-error concept, it is suggested that other technologies should be used.

Another research area may be the determination of the optimal buyout price level in online auctions. If a customer offers the price which was determined by the dealer before the session -named "buyout price"- the session is finished without waiting the close time of the auction. However, if the dealer waits until the end of the auction total time, he/she might sell his/her product for better price. Similarly, if the customer waits, he/she might purchase the product for cheaper price. This could be another further optimization problem waiting to be solved.

Moreover, the models developed for e-markets have been mentioned before. In the papers reviewed for this study, the problems are solved under the assumption that demand is deterministic and it is function of the price. If demand is stochastic the customer will face a more complex optimization problem. In that case, the comparison of the problems solved with deterministic demand and the ones that may be solved with stochastic analysis may be another area of research.

In this paper, a literature survey of OR applications in e-commerce is presented. No extensions of these applications are included here. To sum up, due to the reasons of the significance of e-commerce with respect to theory and practice, and the attractiveness of the difficulties on the researchers faced with its efficient solutions, it can be said that e-commerce will be a promising field for OR practitioners, they will be focusing on the studies in this field for following days.

Internet Addresses (alphabetized, underlined in the main text, all sites begin with http ://)

Amazon (www.amazon.com)
Financial Engines Investment Advisor (www.financialengines.com)

MarketSwitch (www.marketswitch.com)
OptiBid (www.logistics.com/static/static1-1.asp)
Optimal Retirement Planner (www.i-orp.com)
Prentice Hall (www.prenhall.com)
Trajecta, Inc. (www.trajecta.com)
Wikipedia (http://www.wikipedia.org/)

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A CLASSIFICATION MODEL FOR A TWO-CLASS (NEW PRODUCT PURCHASE) DISRIMINATION PROCESS BY USING MULTIPLE CRITERIA LINEAR PROGRAMMING

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ABSTRACT

The purpose of this paper is to outline a new research stream that will focus on the development of a discriminant classification procedure for categorization of product success or failures. The success/failure of each product is based upon their concept and panel score. A key concept in linear programming-based data mining is that the misclassification can be reduced by suing two objectives. One objective is to maximize the minimum distance (MMD) of data records from a critical value. The second objective separates the data records by minimizing the sum of the deviations from the critical value (MSD). Instead of maximizing the MMD or minimizing MSD, a tradeoff between MMD and MSD is found to find a compromise solution.

INTRODUCTION

Discriminant analysis differs from most statistical techniques because the dependent variable is discrete rather than continuous. One might assume that this type of problem could be handled by least squares regression by employing independent variables to predict the value of the value of a discrete dependent variable coded to indicate the group membership of each observation. While this approach may work involving two groups, it can be extended to more than two groups.

Methods of Estimating a Classification Model

Linear Discrimination by the Mahalanobis Method

The objective of discriminant analysis is to use the information from the independent variables to achieve the clearest possible separation or discrimination between or among groups. In this respect, the two group discriminant analysis is no different from multiple regression. We use the independent variables to account for as much of the variation as possible in the dependent variable.

For the discriminant analysis problem, we have two populations that have sets of n_1 and n_2 individuals selected from each population. Moreover, for each individual, there are p corresponding random variables $X_1, X_2, \ldots X_p$. The basic strategy is to form a linear combination of these variables:

$L = B_1X_1 + B_2X_2 + \ldots + B_pX_p,$

And then to assign a new individual to either group 1 or group 2 on the basis of the value of L. The values of $B_1, B_{2,\ldots,}B_p$ are close to provide a maximum discrimination between the two populations. The variation in the values of L should be greater between the two groups than the variation within the groups.

Linear Discrimination by Logit Regression

Both logit choice regression models and discriminant analysis use the same data (a single dependent variable.)

In discriminant analysis, the objective of the Mahalonobis approach is to construct a locus of points that are equidistant from the two group centroids. The distance, which is adjusted for the covariance among the independent variable, is used to determine a posterior probability that can be used as the basis for assigning the observation to one of the two groups. Thus, although the discriminant function is linear in nature, the procedure, also, provides a probability of group membership, i.e., a nonlinear function of the independent variables in the model. When this probability of group membership corresponds to the probability of choice, effectively we have a choice model with a different functional form.

The multiple logistic response function is given by:

$$E(Y) = \frac{e^{B'X}}{1 + e^{B'X}}$$

where Y_i are independent Bernoulli random variables with expected values $E(Y_i) = \Pi_i$

where $E(Y_i) = \Pi = \frac{e^{B'X}}{1 + e^{B'X}}$

The X observations are considered to be known constants. In order to fit this model, the method of maximum likelihood estimates, the parameters of the multiple logistic response function, the fitted logistic response function is fit by $\Pi_i = [1 + e^{-b'X_i}]^{-1}$.

Linear Discrimination by Goal Programming

The approach is based upon the development of the so-called linear discriminant function, where this function is expressed as:

$f(x) = w_1 x_{i1k} + w_2 x_{i2l} + \ldots + w_m x_{ink} + b$

where

x_{ijk} = score achieved by object i, of class k, on attribute j

x_j = weight given to attribute j

b = constant (and unrestricted in sign)

Let us now discuss how one may employ linear programming (LP) to develop this function by means of solving for the unknown weights.

The formulation of the LP model employed to represent the pattern classification problem depends upon the measure of performance selected – and this choice is usually a function of the characteristics of the particular problem encountered. However, two of the most typical measures of performance are those of (1) the minimization of the sum or weighted sum) of the misclassifications and (2) the minimization of the single worst misclassification. In order to keep the discussion simple, we will restrict our focus to training samples from just two classes. Thus, the general formulation of the first LP model (i.e., as used to generate a function that will serve to minimize the use of all misclassifications) is as follows.

Model I
Find w to

$$MIN\ Z = \sum_{i=1}^{p} p_i + \sum_{p+1}^{m} \eta_i$$

$S.T.$

$$\sum_{j=1}^{n} w_j x_{ijk} + b - p_i \le -r \qquad \forall i = 1,..., p$$

$$\sum_{j=1}^{n} w_j x_{ijk} + b - \eta_i \ge r \qquad \forall i = p+1,..., m$$

$$x_{ijk}, p_i, \eta_i \ge 0 \quad \forall i, j, k$$

where

w_j = weight assigned to score (attribute) j (and unrestricted in sign)

$x_{i,j,k}$ = score achieved by object i, of class k, on attribute j

b = constant (and unrestricted in sign)

r = small positive constant (a value of 0.1 is employed here)

$-1 \leq w_j = \leq 1$

i = 1,…,p represents the indices of the objects in the first class

i = p+1, …, m represents the indices of the objects in the second class

The second model (i.e., to develop a function that will minimize the single worst misclassification) is then given as follows:

Model II

Find w so as to

$$MIN\ Z = \delta$$

$$S.T.$$

$$\sum_{j=1}^{n} w_j x_{ijk} + b - p_i \leq -r \qquad \forall i = 1,..., p$$

$$\sum_{j=1}^{n} w_j x_{ijk} + b - \eta_i \geq r \qquad \forall i = p+1,..., m$$

$$x_{ijk}, p_i, \eta_i \geq 0 \quad \forall i, j, k$$

where all notation, as well as the restriction on the upper and lower limits on the weights, is the same as previously defined except that δ denotes the amount of misclassification; Thus, $\delta \geq 0$.

EVALUATING THE CLASSIFICATION FUNCTION

One important way of judging the performance for any classification procedure is to calculate its error rates or misclassification probabilities. The performance of a sample classification function can be evaluated by calculating the Actual Error Rate (AER). The AER indicates how the sample classification function will perform in future samples. Just as the optimal error rate, it cannot be calculated because it depends on an unknown density function. However, an estimate of a quantity related to the AER can be calculated.

There is a measure of performance that does not depend on the form of the parent population, which can be calculated for any classification procedure. This measure is

called the APparent Error Rate (APER). It is defined as the fraction of observations in the training sample that are misclassified by the sample classification function.

The APER can be easily calculated from the confusion matrix, which shows actual versus predicted group membership.

For n_1 observations from Π_1 and n_2 observations Π_2, the confusion matrix is given by the following:

Predicted Memberships

		Π_1	Π_2	
Actual Membership	Π_1	n_1c	$n_1m = n_1-n_1\ c$	n_1
	Π_2	$n_2m = n_2-n_2\ c$	n_2c	N_2

where

n_1c = number of Π_1 items correctly classified as Π_1 items

n_1m = number of Π_1 items misclassified as Π_2 items

n_2c = number of Π_2 items correctly classified as Π_2 items

n_2m = number of Π_2 items misclassified as Π_1 items

The apparent error rate is thus

$$APER = \frac{n_1m + n_2m}{n_1 + n_2}$$

or, in other words, the proportion of items in the training set that are misclassified.

The APER is intuitively appealing and easy to calculate. Unfortunately it tends to underestimate the AER, and the problem does not appear unless the sample sizes of n_1 and n_2 are very large. This very optimistic estimate occurs because the data used to build the classification are used to evaluate it.

The error rate estimates can be constructed so that are better than the apparent error rate, remains easy to calculate and do not require distributional assumptions. Another evaluate procedure is to split the total sample into a training sample and a validation sample. The sample is to construct the classification function and the validation sample is used to evaluate it. The error rate is determined by the proportion misclassified in the validation sample. This method overcomes the bias problem by not using the same data to both build and judge the classification function. There are two main problems with this method:

1. it requires large samples
2. the function evaluated is not the function of interest because some data is lost

AN EXAMPLE PROBLEM FOR A NEW PRODUCT PURCHASE

This paper, focused on the development of a classification procedure for a new financial product service. It is based on a data set which groups purchasers and non-purchasers of the new financial product service. The explanatory variables are income level and saving amount. The data include the training set for developing the discriminant classification model and the validation set for evaluating the model. Three methods of the classification model development will be:

1. discriminant analysis by the Mahalonobis method
2. logistical regression analysis
3. discriminant analysis by multiple criteria linear programming.

These methods and the classification function of each will be evaluated by the error rate they produced.

The future direction of this research will be to employ various multiple criteria linear programming models of the two-class discrimination model in terms of their effectiveness in terms of error rates.

The basic objectives of such models include:

1. maximize the minimum distance of data records from a critical value (MMD)
2. minimize the sum of the deviations from the critical value (MSD)

While the results of these objectives are usually opposite to one anther in terms of results, a combination of these two objectives could provide better results. Various forms of multi-criteria methods will be employed. They will include both pre-emptive and weighted methods, as well as a compromise solution method. The basic data set will consist of a training set of data, and an evaluation set of data. Moreover, the simulation process based on the original data sets of the data set will add to the effectiveness of the study. The classification will be a two set one, including either a purchase or a non-purchase.

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A MULTIPLE OBJECTIVE GOAL PROGRAMMING APPROACH TO THE TRUCKLOAD ROUTING PROBLEM

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ABSTRACT

Truckload routing has always been a challenge. The truckload routing problem (TRP) itself is hard, but the complexity of solving the problem increases due to the stochastic nature of truckload demand. It is traditionally approached through the use of single objective solution methodologies which range from linear programming to dynamic programming techniques. This paper presents a deterministic multiple objective formulation of the TRP, which paves the way for a solution approach utilizing goal programming and taboo search techniques.

Keywords: **multiple objective, truckload routing, triplet**

INTRODUCTION

Multiple Objective Decision Making have been applied to the transportation industry in very limited ways. A great deal of research has been performed however, which integrates characteristics similar to those of the Truckload Routing Problem.

Dallenbach and De Kluyver (1980) used multi objective dynamic programming to find MINSUM and MINMAX solutions to multi criteria decision problems. this extension of dynamic programming handles linear, nonlinear, deterministic and stochastic problems. It is quite well suited for problems involving discrete variables such as the TRP. A single pass of the recursive algorithm produces both single criterion optimal values as well as multi criteria optimal values.

Mutiple objective linear programming and the use of parametric criteria coefficients was presented by Benson (1985). Two or more linear criterion functions which were noncomparable were to be optimized simultaneously over a polyhedral set. Efficient and weakly efficient solutions were considered.

Klein et. al. (1990) focused on interactive multiobjective optimization in cases of problems with uncertainty. Since calculation of a multiattribute utility function can become very consuming in the face of uncertainty, they chose an interactive approach. They developed a two stage model. The first stage variables required immediate decisions and the second stage variables allowed for a deferred decision. The right hand side vectors had associated probabilities to represent the uncertainty.

Stewart (1991) discussed the application of a descriptive approach using non-metric multi-dimensional scaling to represent decision alternatives. The decision make could then easily

identify those alternatives which have the greatest appeal. Multivariate statistical analysis was used to achieve the results.

Serial two-echelon distribution systems with both deterministic and probabilistic demand were addressed by Bookbinder and Chen (1992) and job shop scheduling was addressed by Belton and Elder (1996) proposing a visual interacive model.

Dyer (1972) provided as early discussion of interactive goal programming in solving multi criteria problems. Carrizosa and Romero-Morales (1999) approached multi-objective optimization problems by formulating them as parametric single objective optimization problems. The solution procedure drew its inspiration from goal programming ideas. Minsum and minmax approaches are combined by means of a parameter and applied to classical models in location analysis. Baykasoglu et. al. (1999) and Baykasoglu (2001) explored solutions to goal programming formulations using a taboo search algorithm. An initial solution is generated, followed by the completion of a series of neighborhood searches. Each search results in the selection of a new solution while also building a list of previous locations that become "taboo." Figueira et. al. (1998) applied multi criteria decision making to network flow problems also using a neighborhood search approach.

SINGLE OBJECTIVE TRIPLET TRP FORMULATION

The formulation of the TRP presented in this paper utilizes a triplet concept rather than a lane concept (Miori 2006). The TRP invariably results in a loaded lane movement followed by an empty lane movement, a triplet ties these movements together. The triplet creates a logical connection between the associated loaded and empty movements, though the formulation does allow for two loaded movements as well.

We now consider the definition of a route. Traditionally, a route is composed of a series of lanes to be serviced by a single vehicle. We extend the notion of a route to now consider a series of triplets. We must begin and end a route at the same node, known as a domicile. Multiple domiciles may be present in a single instance of the TRP model, though this thesis addresses only one.

The customers place time conditions, on the handling of freight. Loads must be picked up and/or delivered on particular days of the week during specified times of the day. Some customers will be more restrictive than others in specifying their time windows.

The Department of Transportation (DOT) imposes the remaining conditions. Restrictions are placed on the number of driving hours in a given week and number of work hours in a given week.

We utilize the concept of a triplet. A triplet may be composed of a loaded and empty movement, two loaded movements, or two empty movements. The cost of the triplet is therefore the sum of the costs of the individual movements. The transit and work times are the sums of the transit and work times of the individual movements.

The TRP can be stated as a restricted probabilistic TSP. We customize the standard TSP constraints for our triplet formulation and supplement with load, schedule and triplet feasibility, vehicle utilization, and DOT regulations. Let:

N = the number of nodes,
V = the number of vehicles
H = total allowance of transit hours per route.

The time window specifications are particular to the location of each node. These require the subscript *i,* where $i=1,\ldots,N$.

D_i = Departure time from node,
$[e_i,l_i]$ = early and late arrival times for node *i.*

The demand for service and the travel time are provided for each lane pair. Lanes are designated as *ij* where $i=1,\ldots,N$ and $j=1,\ldots,N$.

y_{ij} = 1 if lane *ij* represents loaded movement
= 0 otherwise.
t_{ij} = time between nodes *i* and *j*.

The costs per triplet per vehicle and the decision variables require three subscripts *i, j* and *k* where $i=1\ldots,N;\ j=1,\ldots,N$ and $k=1,\ldots,N$.

c_{ijk} = Cost to serve triplet *ijk*,
x_{ijk}^{v} = 1 if triplet *ijk* served by vehicle v,
= 0 otherwise.

The objective is stated as a cost minimization function. The

$$Minimize \sum_{\mathrm{i}} \sum_{j} \sum_{k} \sum_{v} c_{ijk} x_{ijk}^{v} \qquad (1)$$

The first constraints represents load satisfaction. They guarantees that each lane pair with demand is traversed at least once. A lane may be served as the first leg of a triplet or as the second leg of the triplet. The nature of the optimization ensures that lanes with no demand would only be used and/or re used for empty movements in support an optimal solution. The triplet formulation combines lane level information with triplet level information.

$$\sum_{v} \sum_{k} y_{ij} (x_{ijk}^{v} + x_{kij}^{v}) = 1 \qquad \forall y_{ij} = 1 \qquad (2)$$

The conservation of flow constraints ensure that every vehicle departs from the final node of every triplet they serve.

$$\sum_{ijlmv}(x^v_{ijk} - x^v_{klm}) = 0 \qquad \forall k \tag{3}$$

The schedule feasibility constraints ensure a logical progression through the routes and forces adherence to time constraints. The time window constraints reflect the individual nodes and not the entire triplet. These are standard constraints used in the TRP.

$$D_i + t_{ij} \le D_j \qquad \forall i, j \tag{4}$$

$$e_i \le D_i \le l_i \qquad \forall i \tag{5}$$

The remaining constraints ensure that routes satisfy the Department of Transportation (DOT) hours of service restrictions. Each route is restricted to a maximum number of hours in transit.

$$\sum_{ijk}(t_{ij} + t_{jk})x^v_{ijk} \le H \qquad \forall v \tag{6}$$

The decision variables must take on binary values.

$$x^v_{ijk} \in (0,1) \tag{7}$$

MULTIPLE OBJECTIVE FORMULATION OF THE DETERMINISTIC TRP

The transition to a multiple objective (MO) formulation requires determination of the multiple objectives. The previous objective of cost minimization remains and additional goals that represent service of all demand, adherence to DOT hours of service regulations and number of routes are introduced.

Before we discuss the specific objectives, we note that the solution approach we will be taking is that of goal programming. Therefore, each objective must have a target value. We then define the positive and negative deviations from this target to be used in the goal programming minimization.

Though the cost minimization was the prevailing objective in the single objective formulation, it will not be the objective with the highest priority in the MO formulation. The objective with the highest priority will be the minimization of unserved loads. Each unserved load is designated by a lane origin and destination. This lane may fall as the first leg of a triplet or as the second leg. We wish to minimize the difference between the loads served and the total number of loads demand in the particular instance of the problem.

$$z_1 = \sum_{ij} d^-_{1ij} \tag{8}$$

The constraint tied to this objective represents the sum of all loads served and only the negative deviation from the goal of serving all demand. Recall from the previous section that the binary

parameters y_{ij} provide a representation of the demand for each lane. A value of zero indicated no demand while a value of one indicates demand available. The positive deviation is not considered since we would be unable to service more demand than was available.

$$\sum_{vk} y_{ij}(x_{ijk}^{v} + x_{kij}^{v}) - d_{1ij}^{-} = 1 \qquad \forall \mathrm{y}_{\mathrm{ij}} = 1 \tag{9}$$

The cost minimization objective falls next in priority order and has a target of zero. We now eliminate the negative deviation from consideration due to the restriction that all costs must be greater than or equal to zero. This approach leaves us with a single deviation measure.

$$z_2 = \sum_{ij} d_2^{+} \tag{10}$$

The associated constraints follow. The cost for each vehicle is accumulated and the positive deviation determined between that cost and the target of zero cost.

$$\sum_{ijkv} c_{ijk} x_{kij}^{v} - d_2^{+} = 0 \tag{11}$$

The objective statement for DOT hours of service regulations is stated as a sum of deviations over all vehicles. In addition, these deviations will now be weighted. The weights on the negative deviations will be negative in value while the weights on the positive deviations will be positive in value.

$$z_3 = \sum_{v} (w_{3v}^{+} d_{3v}^{+} + w_{3v}^{-} d_{3v}^{-}) \tag{12}$$

$$\sum_{ijk} (t_{ij} + t_{jk}) x_{kij}^{v} - d_{3v}^{-} - d_{3v}^{+} = H \qquad \forall \mathrm{v} \tag{13}$$

The final objective is the minimization of the number of vehicles used to achieve a complete routing solution. We are again left with a single value and only positive deviation from the goal of using zero vehicles. as with the coast, we know that achievement of the use of zero vehicles in impossible, but we are unable to clearly and consistently state a maximum number of vehicles for consideration due to the daily changes in the routing problem.

$$z_4 = \sum_{ij} d_4^{+} \tag{14}$$

The constraint for vehicle use follows. The total number of vehicles in use in a particular solution is designated as V. This is the final goal constraint.

$$V + d_4^{+} = 0 \tag{14}$$

We are left to define the remaining constraints of the formulation. These include the conservation of flow constraints, the route sequencing constraints and the binary variable constraints. We may draw these directly from our single objective formulation.

$$\sum_{ijlmv}(x_{ijk}^{v} - x_{klm}^{v}) = 0 \qquad \forall k \tag{16}$$

$$D_i + t_{ij} \le D_j \qquad \forall i, j \tag{17}$$

$$e_i \le D_i \le \mathrm{l}_\mathrm{i} \qquad \forall i \tag{18}$$

$$x_{ijk}^{v} \in (0,1) \tag{19}$$

SOLUTION METHODOLOGY

Goal programming using a tabu search presents very interesting possibilities for the solution of the multiple objective TRP (MOTRP). The procedure would be instantiated with a simple and complete feasible solution to the TRP. This would be the first seed solution and routes would be created by placing a single load, and therefore a single triplet, on each vehicle. This is actually the worst case solution to the problem so an optimal solution must necessarily show improvement over it.

The subsequent neighborhood search requires a single alteration in the seed solution. A load served on an existing simple route, must be added to an alternate route. The simple route would then be eliminated from consideration in the solution. All possible manifestations of this neighborhood would be examine and the change which fulfills the goals most effectively would be chosen to replace the original seed solution.

This approach represents a marked difference in the traditional approach to any type of routing. Routes would typically be built from the ground up. Loads would be added individually to routes. The goal programming approach offers a feasible set of routes at every iteration of the solution procedure. This could result in significant value for TRP dispatchers.

An extension to the formulation to allow stochastic demand is necessary to provide a completely realistic formulation. This increase in complexity in formulation could be easily handled through the use of expected demand functions in lieu of the deterministic demand stated by the y_{ij}s.

CONCLUSION

Research on the TRP can benefit significantly from a goal programming approach, particularly one promoting a tabu search technique. The prioritization of the goals provides an excellent representation of the nature of a dispatcher's thought process. In doing so, the solution procedure becomes more acceptable in an operations environment.

A dynamic programming solution to the goal programming formulation may also offer interesting avenues of continued research. The dynamic programming approach taken by Miori, 2006 required the assignment of penalty weights. Again, attaching a priority sequence to the goals could prove to be quite useful.

References available upon request from Virginia Miori.

Helping the Self Insured Company Select the Right Pharmacy Benefits Manager (PBM) - An AHP-Based Method

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Helping the Self Insured Company Select the Right Pharmacy Benefits Manager (PBM) - An AHP-Based Method

ABSTRACT

A screening model using the Analytical Hierarchy Process (AHP) is developed that facilitates a systematic evaluation of pharmacy benefit managers (PBMs) by incorporating both qualitative and quantitative information into the decision making process. This systematic evaluation is useful in selecting a PBM and assessing their performance, especially by self-insured companies spending millions annually on pharmacy benefits for their current employees and retirees.

I. Introduction

Pharmacy Benefit Managers (PBMs) are an integral part of the delivery of drug benefits for almost all major corporations in the US today. Some well known PBMs are Caremark, Express Scripts, and Medco. One of the major benefits of working with a PBM is a company's ability to improve the use of prescription drugs which should have a simultaneous benefit of higher patient quality of care and a reduction of overall healthcare costs for the corporation involved. Despite PBMs' comprehensive programs, pharmacy costs today continue to escalate, requiring a corporation's benefits manager to evaluate the service PBMs deliver while providing access to drugs medically necessary to treat their employees. This is particularly true for benefits managers at self-insured companies who must not only be concerned about paying for today's prescriptions, but also are aware that less-than-adequate care today will result in higher future expenditures for the firm.

While anecdotal evidence in the healthcare market does provide encouraging information about how PBMs have helped to contain the costs of chronic diseases with programs, benefits managers, especially those at self-insured companies, need to look at all criteria related to the cumulative value a PBM provides to make a fiscally astute and clinically relevant decision about which PBM they will select. Specifically, factors such as drug costs, program services, benefits design, administration and distribution, and employee and retirement assessments are all valid factors that need proper consideration. This study applies the AHP methodology to the PBM selection in the self insured firm by looking at all factors, qualitative and quantitative, necessary for an optimal decision. The result is a dynamic application of the model that can be used by benefits managers to help

determine which PBM is capable of providing the greatest value for the individual self-insured company.

II. A Review of the PBM Literature

. According to Wessel, Wysocki, and Martinez (2006), the cost of healthcare is currently equal to 16.5% of the size of our economy and is expected to rise in the future. While the cost of healthcare has significantly increased during recent years, prescription drug costs now make up the fastest growing segment in overall health care costs today. During the 2001 to 2005 time period, the costs of prescription drugs have increased approximately 27.6% as compared to a 10.4% increase in inflation during the same period (Welch, 2005). Consequently, there is a need to look more closely at the costs of pharmaceuticals, particularly by self-insured employers with rising pharmacy budgets.

Self-insured companies expect that PBMs can perform the basics of claims processing and administration as efficiently and effectively as other insurers, benefit intermediaries, or third-party administrators (TPAs). However, what differentiates PBMs is their ability to implement programs that complement these basic services, such as drug utilization review (DUR) and employee education (Vogenberg and Sica, 2003). As a result, PBMs have emerged as an integral part of the delivery of drug benefits for almost all major corporations in the U.S. and implement pharmacy benefit programs for over 120 million lives or about 70% of the U.S. insured population (Slezak and Stein, 2003).

Many of the self-insured companies have not enjoyed the same revenue growth as PBMs over the distant past. In many cases, the one consistent area of concern for the self-insured company is the recent increases in their annual pharmacy expense budget. This situation has prompted self insured's to request more detail from the PBMs about

the costs associated with their programs and the revenues PBMs generate from acquiring product and adjudicating claims. Armed with the proper questions, self insured companies are beginning to request much more information then they have in the past from PBMs prior to any agreement being signed. According to Wosinska and Huckman (2004), two key points of interest from the self insured's point should be first, the amount and disposition of rebates and administrative fees from drug manufacturers that PBMs are receiving and secondly, the extent to which the PBM is leveraging purchaser relationships to steer business from retail pharmacies to mail order services owned by the PBMs..

As a result, benefits managers of self-insured companies need to be cautious when determining which PBM they will use. Vogenberg and Sica (2003), discuss the use of a request for proposal (RFP) and auditing plan to monitor how well the PBM delivers services both from the perspective of employee and employer satisfaction. Auditing the performance of a PBM is a positive step toward understanding how to get the most out of PBM services, however the self insured may be able to bypass some of these potential problems by using a rigorous evaluation tool such as the AHP process prior to signing the contract. The AHP process could help the self-insured company identify the all around best solution for the pharmacy drug component. Given the increasingly rapid pace of change in the drug benefit market place, comprehensive evaluation of PBMs using a decision support system such as the AHP model may suggest the self-insured companies "go direct" and administer their own in-house pharmacy drug benefit.

III. The Analytical Hierarchy Process

AHP is a multi-criteria decision support system developed by Saaty (1980, 1990) that allows a decision maker to structure a complex problem in the form of a hierarchy. The first level of the hierarchy is the goal. In the present problem, the goal is to evaluate PBMs effectively. The second level includes the criteria. Relevant criteria needed to evaluate PBMs include drug costs, benefits design, program services to assist covered employees, administration and distribution, and employee/retiree assessments.

Depending upon the problem, a third level of the hierarchy may be required. The third level specifies a set of sub-criteria related to the criteria of the second level. For example, a set of sub-criteria must be determined to evaluate the issues related to drug costs, such as brand-generic switches or formulary co-pays. A ratings scale is specified for the criteria and sub-criteria levels. The final level of the hierarchy includes the alternatives to be evaluated. For the present problem, these represent the PBMs which may be evaluated either individually or as a group.

The AHP model has been recently applied to a multitude of different corporate and non-corporate problems to improve decision making (see for example, Liberatore, Monahan, and Stout (1993), Hogan and Olson (2004, 2006), Ishizaka and Lusti (2004), and Travana (2004)). The major advantage of the model is its ability to accommodate complex qualitative and quantitative information into the decision making process. Other advantages include its simplicity to use and its ability to apply consistency to the decision making process.

There are four general steps required to implement the AHP. First, the decision maker identifies the criteria and determines their relative importance in achieving the goal and identifies the sub-criteria and determines their relative importance in achieving

the related criterion. Second, the decision maker determines the relative importance of the ratings categories for each of the sub-criteria. Third, the alternatives are evaluated in the context of each of the ratings categories. Finally, the results are synthesized to compute the relative contribution of the alternatives in achieving the goal.

As stated above, one set of criteria that can be used to evaluate PBMs includes drug cost, benefit design, program services, administration and distribution, and employee/retiree assessment (other criteria, of course, could also be used). Pairwise comparisons must be made to determine the relative importance of the criteria in achieving the goal. Although there are many scales that can be used to compare the criteria, Saaty (1990) recommends a scale from 1 to 9 where 1 refers to "equally important", 3 "moderately more important", 5 "strongly more important", 7 "very strongly more important", and 9 "extremely more important". If more discrimination is necessary, intermediate values, 2, 4, 6, and 8, can be used. For example, if a self-insured company decides that drug costs are “strongly more important” than employee/retiree assessment, a value of 5 is assigned to this comparison.

The results of the comparisons are represented in a pairwise comparison matrix similar to equation (1).

$$= \begin{pmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & \cdots & \cdots & w_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ w_{n1} & w_{n2} & \cdots & w_{nm} \end{pmatrix} = \begin{pmatrix} 1 & w_{12} & \cdots & w_{1n} \\ 1/w_{12} & 1 & \cdots & w_{2n} \\ \cdots & \cdots & 1 & \cdots \\ 1/w_{2n} & 1/w_{2n} & \cdots & 1 \end{pmatrix} \quad (1)$$

where,

w_{ij} = the relative importance of criteria i compared to criteria j; $w_{ij} = 1 \; \forall$ i = j; and $w_{ji} = 1 / w_{ij} \; \forall$ i ≠ j.

If n = 5, *W* will be a 5 x 5 matrix with 1s along the main diagonal depicting comparison of the criteria with itself. Below the main diagonal are the reciprocals of the corresponding comparisons above the diagonal. Thus, in this example a total of 10 comparisons must be made. In general, if there are n criteria to be compared, a total of n(n-1)/2 comparisons are required.

IV. An Application of AHP to Help Select the Right PBM for the Self Insured Company

The application of AHP to choose between various PBMs involves four specific steps:

1. Identify the set of criteria and sub-criteria that will be used to evaluate PBM's.
2. Conduct pairwise comparisons of the relative importance of the criteria (and sub-criteria) in evaluating PBMs, and compute criteria (and sub-criteria) weights based on this information.
3. Obtain data that relates the PBM to the criteria (and sub-criteria).
4. Compute the total assessed weights of the PBM in achieving the goal.

Suppose that a self-insured company wishes to identify which of the PBMs they are negotiating with are most likely to meet the overarching healthcare goals of the company.

Through interviews with benefits managers at self-insured corporations and with consultants to PBMs in the pharmaceutical industry, we have identified five criteria that can be used to identify the optimal PBM. The five criteria are the drug costs (Drug

Cost), pharmacy benefits design (Benefits Design), Program Services (Program Services), Administration and Distribution (Admin. and Distribution), and Employee and Retiree Assessment (Employee/Retiree Assessment).

To understand how these five criteria are integrated into the benefit manager's decision-making process to select a PBM, he/she must consider the changing dynamics of pharmacy benefit management and make discernments about the way their pharmacy benefit can meet employees' needs yet reduce, or at least, contain rising costs. Some key elements of pharmacy benefit management that merit evaluations are discussed below.

- What is the range of drug coverage in tiered-based formularies?
- Is there a use of differential co-payments to guide beneficiaries toward low-cost drugs, usually toward generics and away from brand medicines?
- What is the effect of shift to low-cost drugs on health outcomes?
- Discussion of the number of tiers in formulary. Following Vogenberg and Sica (2003), a company may be interested in a five tier system.
    - Tier #1 – low cost/high value, e.g., certain cardiovascular drugs for high blood pressure,
    - Tier #2 - high cost/high value, e.g., drugs for cancer, depression, asthma or diabetes,
    - Tier #3 - high cost/low value, e.g., certain gastrointestinal drugs for hyperacidity or epigastric problems,
    - Tier #4 - low cost/low value, e.g., certain dermatologic agents
    - Tier #5 – life style drugs, e.g., weight loss, hair loss, contraceptives and antifungal drugs used for nail fungus.

- What is the amount of employee co-payment?
- Is a change in drug cost as a result of manufacturer discount offered for formulary placement (second vs. third tier)?
- Does a prior-authorization requirement exist? For example, does the PBM require that a physician have a medical concern about a patient's response to a generic drug before he/she can prescribe a branded drug?
- Are there step-therapy requirements? For example, is it required for patients to try low-cost medications before the plan covers more costly alternatives?
- Do physician education programs exist that would educate physicians about generic alternatives to brand-name drugs, etc?
- Is there Direct-to-Consumer (DTC) counter-advertising which encourages beneficiaries to discuss generics with their physicians?

These key elements and others like them should be evaluated under the appropriate criterion to assess how well they meet the five identified criteria. This should be done prior to the time the RFP is generated and submitted to candidate PBMs. Given the cost of a self-insured company's pharmacy benefit program, which is millions per month for a large corporation, it becomes apparent that a multi-criteria decision support system, such as AHP, would be extremely useful in selecting which PBM should administer the pharmacy benefit program.

The first step in the process is to construct a pairwise comparison matrix. In Panel A of Table 1 a pairwise comparison matrix is presented for the comparison of the optimal PBM. If the self insured believes that Drug Costs are "moderately more important" than the Benefits Design, a value of 3 is placed in cell w_{12} and .333 is placed

in cell w_{21}. If Drug Costs are "strongly more important" than the Program Services and Employee/Retiree Assessment criteria, a value of 5 is placed in cells w_{13} and w_{15} respectively and .2 in cells w_{31} and w51 respectively. If Employee/Retirement is "equally to moderately more important" than Program Services, then a value of 2 is placed in cell w53 and a value of .5 is placed in cell w35. Other pairwise comparisons for the five criteria are also presented in Table 1.

<Insert Table 1 Here>

The pairwise comparison matrix can be used to estimate the criteria weights. To determine the criteria weights, each column of the matrix in Panel A is summed and each cell is divided by its column total. The result is the adjusted comparison matrix that is presented in Panel B of Table 1. The criteria weights are calculated by computing the average of the entries in each row. In this example, the final weights for Drug Cost, Benefits Design, Program Services, Administration and Distribution, and Employee and Retiree Assessment criteria are .4542, .2670, .0585, .1436, and .0767 respectively. This can be interpreted as Drug Cost criteria being 3.163 times more important than Administration and Distribution criteria (.4542/.1436), 7.764 times more important than Program Services (.4542/.0585), 1.701 times more important than Benefits Design (.4542/.2670), and 5.922 times more important than Employee and Retiree Assessment (.4542/.0767). [1]

Once the criteria weights are computed, the pharmaceutical company can specify a set of sub-criteria and determine their relative importance. Using the approach described above, weights for the sub-criteria can be similarly computed. Alternatively, the decision maker can input the ratings directly. These weights measure the importance

of each of the sub-criteria relative to its criterion. Similar to the set of criteria, the choice of appropriate sub-criteria is dependent upon an evaluation of those factors that can best discriminate among PBMs.

Based on research and survey information with benefits managers, the five criteria can be defined as follows:

- **Drug Cost** includes all activities undertaken to attain a lower cost for drugs, such as rebate negotiation, volume discounts, and extensive use of generics and co-pay amounts.
- **Benefit Design** incorporates the range of access to different drugs and treatment guidelines for patients and providers. It also assesses the PBMs' relationships with state and federal governments and pharmaceutical companies.
- **Program Services** considers the scope of the PBMs programs/services to help plan beneficiaries such as mail order, specialty drug, and educational programs.
- **Administration and Distribution** is the efficiency with which a PBM can process claims (e.g., centralized claims processing), their ability to assess claims often using a Drug Utilization Review (DUR) process, and their effectiveness at getting products to patients with extensive store-front presence and with a well-organized distribution network.
- **Employee/Retiree Assessment** embodies programs centered on patients' health outcomes such as preventative care, disease management, or data evaluation to determine patient compliance. This is important because non-compliant patients could lead to large, more expensive, problems in the future.

Within each of criterion, the sub-criteria enable further differentiation. For example within Drug Costs, brand/generic switch evaluates how aggressive a PBM is getting patients to switch from a brand-name drug to a less-expensive generic drug, e.g., from Zestril®, Astra Zeneca's ACE inhibitor, to Lisinopril, the less expensive generic equivalent of Zestril. The same is true for Rebate Negotiation where the greater the rebate a PBM can negotiate the better (>10% is more desirable than 5-10%) and Formulary Co-pay where a lower co-pay is more desirable for patients (<$10 compared to $10-20). The Wholesale Acquisition Cost (WAC) is what the drug costs the PBM from the pharmaceutical company. Therefore, a lower WAC should mean lower drug costs for the self insured's employees (<WAC is better than WAC).

For the other four criteria, Benefit Design, Program Services, Administration & Distribution and Employee/Retiree, it follows that greater restrictions or better relationships are preferable. As an example, System Parameters that restrict patients to get their drugs from pharmacies within the PBM's network of pharmacies who have agreed to the PBM's terms will have better control over costs than PBMs who allow patients to get their drugs at pharmacies outside the PBM's network (e.g., restrict to within network vs. allow outside network). Of particular importance under Administration & Distribution is efficiency in processing and adjudicating claims or the degree of centralization of claims processing (Central Claims) and the percentage of claims that undergo drug utilization review to make sure the appropriate drug has been prescribed and is being used by the patient (Drug Utilization Review – DUR).

Table 2 presents the criteria and sub-criteria local weights for selecting which PBM to use. The local weight for item i refers to the proportion of value placed on item i

relative to its parent. The weights for the sub-criteria can be determined in the same fashion as those described above. Also listed in Table 2 are ratings scales and their weights for the sub-criteria.

<Insert Table 2 Here>

Suppose the self-insured company determines that the brand/generic switch provides more information concerning drug costs characteristics than rebate negotiations, formulary co-pay, and volume purchasing. This can be incorporated into the weights in Table 2 of the sub-criteria affecting drug costs characteristics. In particular, brand generic is viewed by the self insured company as "moderately more important" than rebate negotiations, "strongly more important" than volume purchasing, and "very strongly more important" than formulary co-pay. Rebate negotiation is determined to be "moderately to strongly more important" than formulary co-pay and "extremely more important" than volume purchasing. Using this information, the sub-criterion weights are computed as .5193, .3204, .0577, and .1025 for brand generic, rebate negotiation, formulary co-pay, and volume purchasing respectively.

The brand/generic switch sub-criteria are rated based on a three point percentage scale. If the brand/generic switch is greater than thirty-three percent, then a weight of .6 is assigned. If brand/generic falls between twenty and thirty-three percent, then a weight of .3 is used. For brand/generic switch less than twenty percent, a weight of .1 is assigned.

The rebate negotiation sub-criteria are rated based on a three-point scale. If the rebate negotiation variable is greater than ten percent, then a weight of .6 is assigned. If

rebate negotiation falls between five and ten percent of the drug cost then a weight of .3 is used. For rebate negotiation less than five percent a weight of .1 is assigned.

The formulary co-pay sub-criteria are also rated based on a three-point scale. If the formulary co-pay is greater than twenty dollars, then a weight of .1 is assigned. If the formulary co-pay falls between ten and twenty dollars, a weight of .4 is used. For a co-pays less than ten dollars, a weight of .5 is assigned.

The volume purchasing is denoted with a three-point scale. If volume purchasing is less than WAC, then a weight of .1 is used. If volume purchasing is equal to WAC, then a weight of .4 is used. For volume purchasing less than WAC, a weight of .5 is assigned.

From prior benefits negotiations a self-insured company determines that when evaluating the Benefits Design aspects of their PBM, established system parameters are "equally to moderately more important" than treatment guidelines, "moderately more important than the PBMs relationship with government programs, and "strongly to very strongly more important" than PBM alliances with pharmaceutical companies. Relationship with government programs is "moderately to strongly more important" than alliances with pharmaceutical companies. At the same time, treatment guidelines are viewed as "moderately more important" than relationship guidelines, but "strongly more important" than alliances with pharmaceutical companies. Using this information, the sub-criterion weights are computed as .4637, .1622, .0592, and .3148 for established systems parameters, relationship with government programs, alliances with pharmaceutical companies, and treatment guidelines respectively.

The established systems parameters sub-criteria are rated based on a three-point scale. If the established systems parameters restrict access to pharmacies outside the PBM's network, then firms would use a weight of .6. If the established systems parameters are within existing parameters a value of .3 is used, and if beyond existing parameters, a weight of .1 is assigned.

The relationship with government programs sub-criteria are rated based on a three-point scale. If the PBM has a positive relationship leading to better coordination of benefits from state Medicaid programs, then a weight of .4 is assigned. If the PBM has a neutral or negative position with the firm then a value of .3 is assigned.

The alliances with pharmaceutical companies' sub-criteria are rated based on a three-point scale. If the alliances are sound and establishes the basis for negotiation on new branded products prior to market launch, then a weight of .4 is assigned. If the alliances are average or weak, then a weight of .3 is used with the possibility of differential weights for both values.

The treatment guidelines sub-criteria are evaluated based on a three-point scale. If treatment guidelines for the patient are enforced, a value of .6 is assigned. If the treatment guidelines are moderately enforced, then a value of .3 is used and, lax, a value of .1 is assigned.

From prior PBM negotiations the factors important for program services were identified as mail order services, specialty drug programs, educational programs for patients, and retail pharmacy interface. Mail order services are identified as "equally to moderately more important" than specialty drug programs and "strongly more important" than educational programs. Specialty drug programs, such as those for transplant

recipients, are referred to as “moderately to strongly more important” than educational programs. Retail pharmacy interface is determined to be “moderately more important” than both mail order services and educational programs, while it is determined to be “very strongly more important” than educational programs. Using this information it is determined that the program services sub-criteria weights are .2550, .1616, .0560, and .5273 for mail order services, specialty drug programs, educational programs, and retail pharmacy interface.

The mail order services sub-criteria are rated based on a three-point scale. If mail order services are available on all drugs with no restrictions, then a weight of .6 is assigned because the PBM’s cost of getting drugs to patients is less expensive. For example, a mail order, 90-day supply incurs significantly lower processing fees than three, 30-day refills for a chronic condition like hypercholesterolemia. If mail order services are available with approval restrictions, then a weight of .3 is used and, if there are limited mail order services, then a weight of .1 is assigned

The specialty drug programs sub-criteria are rated based on a three-point scale where efficient PBMs stress enrollment for patients with disease-specific needs, such as hemophilia. If the specialty drug program has all patients enrolled, a weight of .5 is assigned. If the specialty drug program has a majority enrolled, then a weight of .4 is used and, if less than fifty percent are enrolled, a value of .1 is used.

Educational programs sub-criteria are rated based on a three-point scale and based around the notion that an informed patient is a more prudent consumer. For example, an educational program about the substantial equivalency between brand and generic drugs can improve the PBM’s brand/generic switch percentage. If the PBM has strong

educational programs developed for patient use, then a value of .4 is assigned. If the educational programs have either dedicated staff or respond as needed, a value of .3 is assigned.

The retail pharmacy interface is based on a three-point scale. If the retail pharmacy interface is available to the patient twenty four hours a day, then a weight of .6 is assigned. If the pharmacy hours are between ten and twenty three hours, then a weight of .3 is used and, if they are available less than ten hours, a weight of .1 is assigned.

From an analysis of the negotiations, the self-insured company determines that with respect to administration and distribution of the drugs, a centralized claims processing network is "moderately more important" than a store front presence and "moderately to strongly more important" than an extensive distribution network. The centralized claims network is "strongly more important" than dispensing fees payment and "very strongly more important" than drug utilization review. A store front presence is "moderately more important" than an extensive distribution network and "strongly more important" than both dispensing fees payment and drug utilization review. An extensive distribution network is seen as "moderately more important" than dispensing fees payment and "strongly more important" than drug utilization review. Lastly, dispensing fees payment is seen as "moderately to strongly more important" than drug utilization review. Using this information, the sub-criterion weights are computed as .4582, .2628, .1510, .0874, and .0406 for centralized claims processing, store front presence, extensive distribution network, dispensing fees payment, and drug utilization review respectively.

The centralized claims processing sub-criteria are rated based on a three-point scale and the concept that greater centralization enables greater control and cost containment. If the one hundred percent of the claims belong in a centralized process, a weight of .7 is assigned. If between greater than fifty but less than one hundred percent are centralized, a weight of .3 is used and, if less than fifty percent are centralized, a weight of .1 is used.

The store front presence sub-criteria are rated based on a three-point scale. Despite the convenience of mail order programs, store presence is still pivotal for linking the PBM's drug benefit to patients. Some patients, particularly older ones, just feel more confident getting their prescriptions filled in a drug store. If the there is a store front presence in all regions, then a weight of .6 is assigned. If there is a store front presence between seventy five and ninety nine percent of the time, then a value of .3 is used and, if less than seventy five percent, a weight of .1 will be assigned.

The extensive distribution network sub-criteria are also rated based on a three-point scale and the fact that getting medicines to patients faster is better. If the PBM has a distribution network which allows same-day delivery, then a value of .6 is assigned. If the distribution is overnight, a weight of .3 is used and, if greater than a day, a value of .1 will be required.

Dispensing fees payment sub-criteria are rated based on a three-point scale. If dispensing fees payments take less than five days after submission, then a value of .4 is used. If the payments take between five and ten days, then a value of .4 is used and, if greater than ten days, a weight of .3 is used.

Finally, drug utilization review is based a three point scale. DUR is especially important to ensure that the PBM's treatment guidelines are being met and that patients are being compliant or routinely taking the medicines prescribed for them. If drug utilization review is greater than thirty percent then a value of .7 is used. If drug utilization review is between twenty and thirty percent a value of .2 is used, while if drug utilization review less than twenty percent a value of .1 is used.

Looking at other self-insured companies' PBM negotiations, it is determined that employee/retiree assessment evaluates the PBMs preventative care, integration of data, disease management, and compliance. The integration of data is "moderately more important" than the preventative care. Disease management is "strongly more important" than the preventative care and "moderately more important" than integration of data. Compliance is "very strongly more important" than preventative care, "strongly more important" than integration of data, and "moderately more important" than disease management. Using this information, the sub-criteria weights are determined to be .0569, .1219, .2633, and .5579 for preventative care, integration of data, disease management, and compliance respectively.

AHP can help the self-insured company focus on the determination of the weights or "priorities" of each criteria and sub-criteria in accomplishing the goal. The weights represent the relative importance the self insured company places on each of the attributes. Once the weights for each of the attributes are determined, the company can assess a PBM on each of the attributes and determine whether any of the PBMs under consideration should be used to deliver the drug benefits for the corporation or if the self-insured company should perhaps take over the job themselves.

Table 3 presents the global weights for the entire PBM hierarchy of our hypothetical self-insured firm. The global weight for item i refers to the proportion of total value placed on item i by the benefits manager. Global weights are computed by multiplying the local weight of the item by the local weight of each of its parents. For example, suppose the self-insured company believes formulary co-pays for the PBM will be between ten and twenty dollars. From Table 2 we observe that the local weight for formulary co-pay between ten and twenty dollars is .4, the local weight for formulary co-pay is .0577, and the local weight for drug costs is .4542. Thus, the global weight for formulary co-pay between ten and twenty dollars is .0105. Other global weights in Table 3 are compute in a similar fashion.

<Insert Table 3 Here>

Once the global weights have been determined, the self-insured company gathers information concerning PBMs that it is evaluating. Table 4 presents hypothetical data for three PBMs that will emerge from the negotiations process. Each of the PBMs is rated based on the sub-criteria. For example, the brand/generic switch for PBA A and C is expected to be greater than 33%, while PBA B is expected to be between 20 -33%. Thus, using the data from Table 3, PBM A and C earn a score of .142 for brand/generic switch and PBM B earns a score of .071 for brand generic.

<Insert Table 4 Here>

The scores for all of the ratings are summed and an overall score is determined. For the three PBMs depicted in Table 4, PBA A earns a total of .523, PBA B earns .302 and PBA C earns .396. Once the total scores have been computed, a decision can be made whether to work with any of the PBMs based on all the current information

concerning the pharmacy benefits. The self-insured company can either choose a minimum cut off for the PBM to justify a relationship or further segment the scores into categories of high likelihood of company and patient satisfaction, further investigation warranted, or low probability of company and patient satisfaction. For example, using our hypothetical PBMs, the self-insured company may want to reject any PBMs with scores less than .350, further investigate compounds with scores between .351 and .450, and seriously consider PBMs with scores greater than .451. The result is a structured framework that integrates both qualitative and quantitative information to evaluate all PBMs on the same scale to determine whether they are likely to fill the needs of both the company and the patient regarding pharmacy benefits management.

V. Model Validation

In the above example, the expert knowledge of the self-insured company's benefits manager is used to conduct pairwise comparisons. Because the resulting PBM selection process is dependent upon these comparisons, it is desirable to use the optimal set of criteria and their relative importance. Unfortunately, no researcher has yet identified the optimal set of criteria that can be used to evaluate all PBMs and, depending on the PBM, these variables could also change. The model presented here integrates information from both academic research studies and actual benefits manager practice to build the best model that can incorporate both quantitative and qualitative data into the PBM process.

AHP is a multi-criteria decision support system that can integrate quantitative and qualitative information. The value of the model is dependent upon the inputs of the

expert. Until an optimal set of criteria can be identified for each possible compound, care should be taken in the selection of the relevant inputs in evaluating PBMs.

For self-insured companies, the model can be used as a focal point for rethinking the tradeoffs among different sets of criteria that are pertinent to the important question of which PBMs would fill the companies' and patients' needs. The simplicity of implementing AHP permits the self-insured company to easily revise the criteria based upon different situations that may arise while evaluating different PBMs. Model parameters can be modified until the AHP rankings of analyzed PBMs are consistent with post RFP information supplied as a result of the current PBMs effectiveness. Not only will the output of the model be improved but also valuable insight can be gained that may eventually lead to the identification of an optimal set of criteria to evaluate PBMs and thus save the company from using the wrong PBM for their current and past employees.

VI. Summary and Conclusions

The effective evaluation of PBMs involves both subjective and objective information. A difficulty arises in the implementation of the process due to multiple evaluative criteria that may be troublesome to measure. AHP is a decision support system that can integrate both subjective and objective information to improve the efficiency selecting the "optimal" PBM to implement a self-insured company's pharmacy benefit program.

AHP requires the structuring of the problem into the form of a hierarchy, which consists of a goal, evaluation criteria, and possibly sub-criteria, and alternatives. Pairwise comparisons are made on items on each level of the hierarchy to the level above it and the relative importance of the items is determined. An overall score for each

alternative is computed and can be contrasted to a benchmark established by the decision maker.

In this paper, we described AHP and applied the model to the evaluation of PBMs. The result is a flexible and consistent scoring model that can improve the selection of a PBM, thereby more effectively containing program costs as well as enhancing benefits to covered employees and retirees. AHP is flexible in that the criteria and sub-criteria can be revised based upon the needs of the user. Also, the relative importance of the criteria and sub-criteria can be easily recomputed with the use of a spreadsheet or dedicated software. The result is a consistent and effective measurement scale that can be used to evaluate the difference between a PBM that only meets requirement of a third-party administrator and one that helps an employer reduce costs by implementing programs to improve patient outcomes.

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TABLE 1
PAIRWISE COMPARISON MATRIX AND
COMPUTATIONS FOR PBM EVALUATION CRITERIA

PANEL A: PAIRWISE COMPARISON MATRIX

	Drug Cost	Benefits Design	Program Services	Admin. & Distribution	Employee/ Retiree Assessment
Drug Cost	1.0000	3.0000	5.0000	4.0000	5.0000
Benefits Design	0.3333	1.0000	4.0000	3.0000	5.0000
Program Services	0.2000	0.2500	1.0000	0.3333	0.5000
Admin. & Distribution	0.2500	0.3333	3.0000	1.0000	3.0000
Employee/Retiree Assessment	0.2000	0.2000	2.0000	0.3333	1.0000
Column Total	1.9833	4.7833	15.0000	8.6667	14.5000

PANEL B: ADJUSTED COMPARISON MATRIX AND CRITERIA WEIGHTS

	Drug Cost	Benefits Design	Program Services	Admin. & Distribution	Employee/ Retiree Assessment	Criteria Weights
Drug Cost	0.5042	0.6272	0.3333	0.4615	0.3448	0.4542
Benefits Design	0.1681	0.2091	0.2667	0.3462	0.3448	0.2670
Program Services	0.1008	0.0523	0.0667	0.0385	0.0345	0.0585
Admin. & Distribution	0.1261	0.0697	0.2000	0.1154	0.2069	0.1436
Employee/Retiree Assessment	0.1008	0.0418	0.1333	0.0385	0.0690	0.0767
					Total	1.0000

TABLE 2
PBM EVALUATION CRITERIA AND SUB-CRITERIA
LOCAL WEIGHTS

Drug Costs .4542		Benefit Design .2670		Program Services .0585		Admin & Distribution .1436		Employee/ Retiree .0767	
	> 33% .6		Restrict .6		All .6		100% .7		Wellness Program .3
Brand/ Generic Switch .5193	20-33% .3	System Parameters .4637	Within .3	Mail Order .2550	Approval Required .3	Central Claims .4582	50-99% .2	Preventive Care .0569	Annual Physical .5
	<20% .1		Beyond .1		Limited Use .1		> 50% .1		Physical Every 2 yrs. .2
	>10% .6		Positive .4		All Enrolled .5		All regions .6		Fully Integrated .5
Rebate Neg. .3204	5-10% .3	Relationship with Gov. .1622	Neutral .4	Specialty Drug Program .1616	Majority Enrolled .4	Store Front Presence .2628	75-99% .3	Integration of Data .1219	Somewhat Integrated .3
	<5% .1		Negative .3		<50% Enrolled .1		<75% .1		Not Integrated .2
	< $10 .5		Sound .4		Programs Developed .4		Same Day .6		Coordinated .6
Formulary Co-pay .0577	$10 – 20 .4	Alliance with Pharma .0592	OK .3	Educationa l Programs .0560	Dedicated Staff .3	Extensive Distribution .1510	Over-night .3	Disease Management .2633	Somewhat Coordinated .3
	> $20 .1		Weak .3		Respond as Time Permits .3		1 Day .1		Not Coordinated .1
	< WAC .5		Enforced .6		24 hour .6		<5 days .4		80-100% .7
Volume Purchasing .1025	WAC .4	Treatment Guidelines .3148	Moderate .3	Retail Pharma Interface .5273	10 – 23 hour .3	Dispensing Fee Payment .0874	5-10 days .3	Compliance .5579	50-79% .2
	> WAC .1		Lax .1		< 10 hours .1		>10 days .3		> 50% .1
							>30% .7		
						DUR .0406	20-30% .2		
							<20% .1		

TABLE 3
COMPOUND EVALUATION CRITERIA AND SUB-CRITERIA
GLOBAL WEIGHTS

Drug Costs		Benefit Design		Program Services		Admin & Distribution		Employee/ Retiree	
	> 33% .1415		Restrict .0743		All .0090		100% .0461		Wellness Program .0013
Brand Generic .2359	20-33% .0708	System Parameters .1238	Within .0371	Mail Order .0149	Approval Required .0045	Central Claims .0658	50-99% .0132	Preventive Care .0044	Annual Physical .0022
	<20% .0236		Beyond .0124		Limited Use .0015		> 50% .0066		Physical Every 2 yrs. .0009
	>10% .0873		Positive .0173		All Enrolled .0047		All regions .0226		Fully Integrated .0047
Rebate Neg. .1456	5-10% .0437	Relationship with Gov. .0433	Neutral .0130	Specialty Drug Program .0095	Majority Enrolled .0038	Store Front Presence .0377	75-99% .0113	Integration of Data .0093	Somewhat Integrated .0028
	<5% .0146		Negative .0130		<50% Enrolled .0009		<75% .0038		Not Integrated .0019
	< $10 .0131		Sound .0063		Programs Developed .0013		Same Day .0130		Coordinated .0121
Formulary Co-pay .0262	$10 – 20 .0105	Alliance with Pharma .0158	OK .0047	Educational Programs .0033	Dedicated Staff .0010	Extensive Distribution .0217	Over-night .0065	Disease Management .0202	Somewhat Coordinated .0061
	> $20 .0026		Weak .0047		Respond as Time Permits .0010		1 Day .0022		Not Coordinated .0020
	< WAC .0233		Enforced .0504		24 hour .0185		<5 days .0050		80-100% .0299
Volume Purchasing .0466	WAC .0186	Treatment Guidelines .0840	Moderate .0252	Retail Pharma Interface .0309	10 – 23 hour .0093	Dispensing Fee Payment .0126	5-10 days .0038	Compliance .0428	50-79% .0086
	>WAC .0047		Lax .0084		< 10 hours .0031		>10 days .0038		> 50% .0043
							>30% .0041		
						DUR .0058	20-30% .0012		
							<20% .0006		

TABLE 4
EVALUATION OF COMPETING PBM'S

	PBM A	WEIGHT	PBM B	WEIGHT	PBM C	WEIGHT
DRUG COSTS						
Brand/Generic Switch	>33%	0.142	20-33%	0.071	>33%	0.142
Rebate Negotiation	>10%	0.087	5-10%	0.044	5-10%	0.044
Formulary Co-pay	$10-$20	0.010	$10-$20	0.010	$10-$20	0.010
Volume Purchasing	>WAC	0.023	WAC	0.019	>WAC	0.023
BENEFITS DESIGN						
Establish System Parameters	restrict existing parameters	0.074	restrict existing parameters	0.037	within existing parameters	0.037
Relationship with Government Program	neutral	0.013	neutral	0.013	neutral	0.013
Alliances with Pharma Companies	sound	0.006	sound	0.006	sound	0.006
Treatment Guidelines	enforced	0.050	moderate	0.025	moderate	0.025
PROGRAM SERVICES						
Mail Order Services	approval required	0.004	approval required	0.004	limited use	0.001
Specialty Drug Programs	majority enrolled	0.004	majority enrolled	0.004	<50% enrolled	0.001
Educational Programs	dedicated staff	0.001	dedicated staff	0.001	respond as time per.	0.001
Retail Pharma Interface	10-23 hours	0.009	10-23 hours	0.009	10-23 hours	0.009
ADMINISTRATION AND DISTRIBUTION						
Centralized Claims Processing	100%	0.046	50-99%	0.013	100%	0.046
Store Front Presence	75-99%	0.011	75-99%	0.011	<75%	0.004
Extensive Distribution Network	same day	0.013	overnight	0.007	overnight	0.007
Dispensing Fees Pmt	5-10 days	0.004	5-10 days	0.004	>10 days	0.004
Drug Utilization Review	>30%	0.004	>30%	0.004	>30%	0.004
EMPLOYEE/RETIREE ASSESSMENT						
Preventive Care	annual physical	0.002	annual physical	0.002	wellness program	0.001
Integration of Data	somewhat integrated	0.003	somewhat integrated	0.003	somewhat integrated	0.003
Disease Management	somewhat coordinated	0.006	somewhat coordinated	0.006	somewhat coordinated	0.006
Compliance	50-79%	0.009	50-79%	0.009	50-79%	0.009
TOTAL		**0.523**		**0.302**		**0.396**

FOOTNOTES

[1] The procedure presented here is good approximation of the weights. Saaty (1980) determined the exact relative priorities for each of the n criteria by computing the normalized eigenvector of the maximum eigenvalue of the comparison matrix. The normalized eigenvector is computed by raising the comparison matrix to successive powers until convergence is achieved and then normalizing the results.

A MULTIPLE CRITERIA APPROACH TO CREATING GOOD TEAMS OVER TIME

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ABSTRACT

A common problem that exists in many team based programs is the process by which the teams are chosen. This selection process is critical since teams are determined at the beginning of the class/program and may change from semester to semester or remain the same throughout the entire class/program. Team selection approaches range from letting the students decide to the program director assigning them based on some criterion, such as geographic proximity or on educational skill sets. All these selection procedures have several shortcomings from an academic and students' point of view. This paper will describe a multiple criteria approach to this team selection problem that balances students' skill sets among the groups and varies the composition of the teams from semester to semester. The results of applying this team selection model to our EMBA program are presented.
(Keywords: Group Formation, Multi-Criteria Decision Making, Mathematical Programming/ Optimization, Decision Support Systems)

INTRODUCTION

The goals of most undergraduate and graduate business programs can be stated as being designed to educate its students into becoming leaders who think critically, plan strategically, and act decisively in an increasingly competitive and global economy. An integral part of these programs includes team assignments. A major reason for team work is that in the real-world, in most cases, an individual does not work in isolation, but with other people. Students, future managers/workers, must learn how to work with their colleagues. The team assignments, therefore, provide the students with a direct experience of the dynamics of group work.

Team assignments are in some programs a key, if not necessary, requirement. For example, most EMBA programs are lock-step intensive programs. In such programs, teams can be used to assist each other in completing class assignments, studying for exams, and intensive interaction on case studies.

The process of team selection has usually not been ideal. Teams are most likely formed by one of two ways, [1]:

- randomly: the professor allows the students to form their own groups with only a limitation of the group size, [2] or
- the professor or program director assigns students according to some specific criteria/characteristic, e.g., each group must have a finance major, [2].

Because teams are such an important ingredient in the EMBA program and other lock-step, cohort type programs, their formation is critical to the success of the program. Teams are formed during the orientation phase of the program. Factors that go into the composition of the team include technical expertise, geography, and personal chemistry. Since the teams will be facing a variety of challenges it is important that each team exhibits a diversity of skills, a relative convenience to meet and work together, and an ability to pull together in times of adversary. The emergence of the WEB has markedly enhanced the opportunities for communication.

At our University, the process of determining EMBA teams, in the past, had each student choosing their teammates during a single event at the end of the orientation process. More specifically, all the students are brought into a room and are instructed to form teams of between 4 and 6 members. Additionally, they are instructed that the entire group is not allowed to leave the room until all of the students are a member of a team. The students are encouraged to take into consideration one another's various skills and Myers-Briggs Type Indicator. This process has its limitations in that the choices are generally made very quickly, without a great deal of thought and planning. Additionally, the process tends to be extremely stressful for introverted personality types. Students have commented that the experience can be compared to choosing teams in elementary school.

Given the above situation, the model for developing teams that is set forth in this paper provides a more objective basis for team formation.

MODEL

The team formation model is formulated as the following multiobjective nonlinear integer programming model:

$$\text{Min: } w_1 \sum_{i=1}^{P} v_i + w_2 [\underset{j}{Max}(\sum_{m=1}^{M} f_{mj}) - \underset{j}{Min}(\sum_{m=1}^{M} f_{mj})] + w_3 \sum_{m=1}^{M} [\underset{m}{Max} \sum_{j=1}^{J} f_{mj} - g_m] \quad (1)$$

st.

$$\sum_{j=1}^{J} x_{ij} = 1 \qquad \forall\ i \quad (2)$$

$$\sum_{i=1}^{P} x_{ij} = S_j \qquad \forall\ j \quad (3)$$

$$\underset{j}{Max}\ (x_{ij} + x_{kj} - 1) = d_{ik} \quad \forall\ i,k \quad (4)$$

$$v_i = \sum_{k=1}^{P} e^{(d_{ik} r_{ik})} - 1 \qquad \forall\ i \quad (5)$$

$$f_{mj} = \sum_{i=1}^{P} y_{im} x_{ij} \qquad \forall\ m,j \quad (6)$$

$$x_{ij},\ d_{ik} = [0,1] \quad \forall\ i, j, k$$

$$f_{mj} \geq 0 \qquad \forall\ j,m$$

where:
i: student i i = 1, . . ., P
k: student k k = 1, . . ., P

j: group j j = 1, . . ., J
m: skill m m = 1, . . ., M
D: desired group size
P: total number of students
J: number of groups = Int(P/D); where Int rounds off the number to an integer
N : total number of possible students where each group has the same number of students = D*J
M: total number of skills

Parameters

S_j: total number of students to be assigned to group j

$$= \begin{cases} D & j = 1, \ldots, N \\ D+1 & N+1, \ldots, P \end{cases}$$

h_{ik} = number of times student i and student k have been in the same group

r_{ik}: a penalty for historically how many times student i and student k have been in the same group

$$= \begin{cases} 0 & \text{if } h_{ik} = 0 \\ 5^{(h_{ik}-1)} & \text{otherwise} \end{cases}$$

$$y_{im} = \begin{cases} 1 & \text{if student i has skill m} \\ 0 & \text{otherwise} \end{cases}$$

g_m: minimum projected number of students with skill m in a group

$$= Int\left(\frac{\sum_{i=1}^{P} y_{im}}{J} \right) \quad \forall m$$

Decision variables

$$x_{ij} = \begin{cases} 1 & \text{if student i assigned to group j} \\ 0 & \text{otherwise} \end{cases}$$

$$d_{ik} = \begin{cases} 1 & \text{if student i and student k are assigned to same group} \\ 0 & \text{otherwise} \end{cases}$$

f_{mj} = sum of students with skill m in group j

v_i = weighted penalty for the number times student i is assigned a group with students he / she has already been with

The team formation model has three objectives, (1), to:

· minimize the number of times, more than once, that a student is in the same group with individuals he/she already has been in the same group,

· minimize the difference between the maximum and minimum of the sum of the skills in a group, i.e., minimize the range/difference, and;

· minimize the sum of the differences for all skills between the maximum number of students with a particular skill in all the groups and the desired minimum number of

students with that skill.

Constraint (2) assures that each student is assigned to one and only one group. Constraint (3) makes sure each group j is assigned S_j students. Constraint (4) defines d_{ik} as equaling 1 if student i and student k are in the same group, otherwise d_{ik} is equal to 0. In particular, given a pair of students i and k, we have the possible combinations and corresponding results listed in Table 1 below.

x_{ij}	x_{kj}	d_{ik}	Results (considering all groups j)
0	0	-1	It can not occur because each student must be assigned to a group, (2).
1	0	0	In this situation, student i and student k are in different groups.
0	1		
1	1	1	In this situation, student i and student k are in the same group.

Table 1. Values of $d_{ik.}$

The variable d_{ik} significantly decreases the model size by astutely requiring us to only generate one PxP matrix instead of J PxP matrices.

Constraint (5) defines the weighted penalty for each student i, v_i, for being more than once in the same group with other students. First, r_{ik}, is a penalty for being historically in the same group with another student. Table 2 lists some of the possible r_{ik} penalty values. In the current model being executed, if two students are not in the same group then d_{ik} will be equal to 0, and hence, $d_{ik}r_{ik}$ will equal 0, regardless if they were previously in the same group. If two students are in the same group then d_{ik} will equal 1. If the two students were never in the same group prior to this model execution (or semester run), then $h_{ik} = r_{ik} = 0$ and therefore, $d_{ik}r_{ik}$ will still be equal to 0. On the other hand, if two students are in the same group, $d_{ik} =1$, and they were previously in the same group, perhaps, one or more times, then, $d_{ik}r_{ik}$ is weighted exponentially. For example, if it is the second time two students, i and k, are in the same group, then, $d_{ik}r_{ik}$ will equal 1. As a result, in constraint (5), v_i is defined as an aggregate penalty, for student i, being assigned to a group, in this current model execution, with one or more students that he/she has previously been in identical groups. And the weighted sum of these v_i characterize the first objective.

Number of times in the same group, h_{ik}	0	1	2	3
Penalty, r_{ik}	0	1	5	25

Table 2. Values of r_{ik} and v_i.

Constraint (6) defines f_{mj} as the sum of students with skill m in group j. This variable, f_{mj}, is used to depict the second and third objectives. The expression $\sum_{m=1}^{M} f_{mj}$ sums all skills in a group.

The second objective takes the difference between the maximum and the minimum of this sum and attempts to minimize this difference, thus trying to balance the aggregate skills among the groups. The third objective attempts to balance the individual skills among the groups by minimizing the weighted sum of the difference between the maximum number of students with skill m and the desired minimum, g_m, for each skill m.

APPLICATION

This team formation model has been successfully applied for the past three semesters, for three cohorts. The model is executed before to each semester. Parameters h_{ik} and r_{ik} are updated based on last semester's team assignments. Additionally, since some students leave the program, for various reasons, personal and academic, so some other parameters must also be updated, i.e., D, P, J, N, S_j, and g_m. Responses from students and administration to the team formation process, thus far, have been extremely positive.

The above multiobjective nonlinear integer programming model has been solved in Excel using Crystal Ball's add-in Optquest. Optquest incorporates simulation and optimization in a software package that integrates a scatter search / tabu search module, a mixed integer programming solver, and a procedure to configure and train neural networks. Initially, an older version of Crystal Ball's Optquest, (Version 2000) was used and solution times varied from 20 to 40 minutes on a Pentium M 780 / 2.26 GHz. Optquest took a long time to search and solve each trial solution. Recently, we updated our version of Crystal Ball to 7.2 and search and solution times have significantly decreased. Solution times are now less than 7 minutes.

CONCLUSIONS

The process of developing teams, especially for lock-step, cohort type programs, such as an EMBA program, may be critical to the class or program's success. We have developed and successfully applied a multiobjective nonlinear integer programming team formulation model to objectively determine group compositions. In the future, we will extend the model to consider possible other objectives, such as team "loafing" and possibly applying the model in other team oriented programs and individual classes.

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VERTICAL PERFORMANCE MEASUREMENT IN BUSINESS INCUBATORS: ISSUES AND OPPORTUNITIES

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ABSTRACT

Traditional measures of performance in incubators do not adequately assess performance nor accurately measure inputs and outputs. Tenant-customers' perceptions of the services provided, and their participation and input are an important component of service performance, and effectiveness. This paper proposes a new framework for evaluating and measuring incubator service performance entitled 'Vertical Performance Management'. The framework is applied to business incubators and the incubation process. Propositions for business incubators' performance assessment and future research conclude the paper.

Business Incubators; Performance; Satisfaction; Strategic Decision Making

INTRODUCTION

Attempts to improve Incubator Service Performance (ISP) and Tenant Customer Satisfaction (TCS) underlie the basic confrontation between the efficiency required of ISP and the effectiveness desired for TCS. Processes like customer relationship management, total quality management, continuous improvement, sigma 6, and ISO 9000 are some of the management methods and techniques used by business and other organizations to facilitate and address this dichotomy.

Business incubators evolved so as to increase the survival rates of start-up businesses, while increasing employment opportunities and economic activity in their communities. Incubators help new businesses grow by providing a protective umbrella on their road to self-sufficiency and success (Laric, 2005). The last two decades of the 20th century gave birth to business incubators. The number of incubators increased 1000 fold (from 4 in 1980 to 4000 in 2000 (Barrow, 2001). Incubators were established by business, academia and public sector concerns, their missions expanded and their geographic spread now covers several continents. More information on the variety and types of incubators is on (http://www.nbia.org).

The need to simultaneously improve incubator service-performance (ISP) and tenant-customer satisfaction (TCS) complicates the management task in incubators. ISP and TCS are critical determinants of long-run performance, and their mutual pursuit often requires significant trade-offs in the short run.

Incubator performance is assessed using measures such as occupancy rates, dollars spent per tenant customer, and tenants' graduation rates. Adding satisfaction measures to the above is essential if incubators are to increase ISP in both efficiency and effectiveness. This linkage is

particularly critical because tenant-customers' input to the incubation process is critical to the overall successful performance of incubators, thus increasing both ISP and TCS.

This article first explores issues concerning ISP, and TCS. It proceeds to integrate both into a framework entitled Vertical Performance Management (VPM); VPM is next applied to business incubators as a means of further clarifying the use of the VPM approach. Propositions for future research conclude the paper.

MEASURING ISP AND TCS

The marketing concept asserts that increasing customer satisfaction leads to customer retention which can result in developing an on-going relationship with customers; these should be encouraged by management (Kotler, 2005). Customers' input to facilitating service transactions affects ISP and therefore their perspectives should be explicitly included in ISP measurement.

Since incubator services are often provided and consumed simultaneously, ISP is affected by variations in customer inputs which, in turn, are a function of their expectations. The alignment of customer expectations with their input is a critical dimension of both ISP and TCS. Tenant-customers' inability to examine and experience incubator services prior to entering the incubator (Chadwick, 2000) complicates TCS by introducing subjectivity into their expectations. Potential tenants must therefore rely on the incubator's reputation, perceived attributes, and verbal and visual cues to serve as a proxy of ISP evaluation. Consequently, the incubator manager's skill in public relations may determine tenant-customer perceptions regarding ISP as much (and at times, more) than actual services provided, imparted knowledge and experience shared.

Prior to entering an incubator, tenants sign a contract for the space to be rented and the accompanying services. Tenants sign a contract based o reputation and a 'promise' to provide TCS. Thus, for a given level of service rendered, tenant-customers may have different levels of expectations, leading to variations in performance perceptions and with it, to different levels of TCS. We incorporate these issues and concepts into the VPM framework.

VERTICAL PERFORMANCE MANAGEMENT (VPM) FRAMEWORK

The definition of relevant inputs and outputs in incubators must incorporate both ISP and TCS perspectives. The traditional efficiency measure (an input/output ratio) must be extended to include effectiveness: TCS and their perception of the effectiveness of the ISP. Adding effectiveness to efficiency measures requires a customer oriented concept of performance assessment and measurement which extends the incubator management concerns vertically. Such performance measures encourage consideration of ISP efficiency with TCS effectiveness (e.g., how "good" is the service quality).

ISP efficiency is determined mainly by the ratio of inputs to outputs, reflecting capacity utilization on both quantitative (e.g. rents) and qualitative (e.g. services rendered) dimensions. This level of utilization depends upon the incubator's capability (in this context, a term which emphasizes both quality and quantity of the incubator's space availability and service provision capacity. These would ideally be based on estimates of demand for the incubator's services, the

political and community support (and the resources available) as input to creating the incubator. Creation of the incubator assumes that a strategy for certain levels of services and ISP was planned for. Some excess capability is essential if incubators' management anticipates successful performance and wishes to meet future growth in demand, or avoid lost 'rentals' due to lack of space.

Tenant customers affect ISP by their input into the exchange relationship between tenant customers and incubator management. These inputs are influenced by the physical, financial, and other efforts expended by the incubator to obtain the desired levels of ISP. This effort should also include TCS which in turn is affected by tenant-customer expectations. These expectations reflect their general attitudes toward the types and levels of benefits to be realized from the ISP, based on information gathered and past experiences.

The introduction of customer expectations and incubator estimates of demand into the VPM framework facilitates the linkage of ISP concerns to TCS. TCS can be assessed by estimating the difference between the customers' expectations and their perceptions of ISP. The analysis of gaps, if any, between expectations and perceived performance is an appropriate beginning for incubator management and their performance improvement efforts. Such efforts should also recognize the problem of unreasonable or unrealistic expectations which may lead to inherent dissatisfaction among some tenant customers.

The relationships among expectations, performance and satisfaction may be viewed schematically as the fundamental triangle of tenant-customer behavior. Figure 1 portrays the TCS triangle, or the tenant-consumer's view of service relationships (an often neglected yet all too important component of ISP.) In this triangle, levels of perceived ISP and customers' expectations increase when moving from their intersection point upwards along the performance axis, or to the left along the expectations axis. (Point A, Figure 1).

The level of satisfaction increases from the point of its intersection with the expectations axis to the point where it intersects with the performance axis. This schematic portrayal implies that a incubator manager can increase TCS along two dimensions: (1) by improving his ISP as perceived by his customers; or (2) by aligning tenant customers' expectations to the levels of ISP the incubator can achieve and the tenant customers' perception of the ISP level – a strategic move.

Customer expectations are mainly influenced by: (1) past experiences with respect to the particular set of services received; and (2) exposure to competitive service offerings available to the potential tenant- customer outside the incubator. A change in perceived performance (horizontal alignment) requires a tactical change. Perceived performance focuses on the perceived adequacy, in terms of a threshold level, below which the service is unacceptable. It depends on the service mix, its availability and cost of obtaining benefits.

Moving to the ISP view 9figure 2), the incubator's ability to provide service is defined above as its capability and reflects their maximum rental space and service provision potential. For example an incubator's overall size in square feet and the ability to provide utilities such as internet connections define its capability which can reach the maximum (100%) capability and

depending on the number of personnel and service level, potential quality levels for the service to be provided is assessed. Changes in service capability (horizontal line) reflect strategic management decisions: for example increasing the facility or acquiring another location. Conversely, changes in service levels are tactical in nature (vertical line) and represent the hiring of an additional receptionist, or adding a marketing expert to the staff.

The service level reflects utilized capacity (percent of capability utilization by time period) and depends on the scale of operations, the cost structure and demand patterns. The resulting ISP focuses on expected efficiency. It also depends on the available pool of new tenant customers and expected graduation rates; an alignment of capability and service levels to yield higher ISP.

Figure 1: The TCS Triangle – the Tenant-Customers' View of ISP

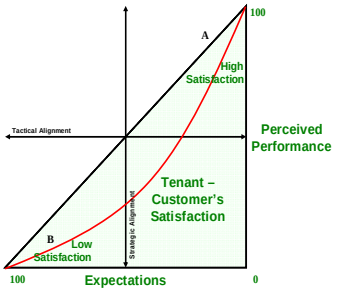
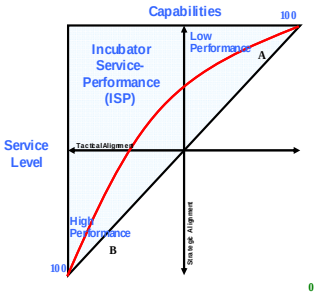
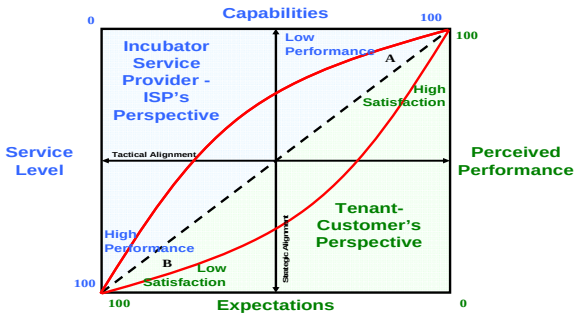


Figure 2: The ISP Triangle – the Incubators' View of Services



Combining the two triangles and integrating them to form a Vertical Performance Management System is portrayed in Figure 3.

Figure 3: The Vertical Performance Management System



ISP which is usually measured by incubator managers as an input/output efficiency ratio is broadened by the VPM framework so as to explicitly incorporate customer's satisfaction. The VPM framework highlights the tradeoffs between ISP and TCS which marketers characterize as a shift in decision making focus from "production" to customer orientation.

For example if capability is high and the level of services provided is low, performance is likely to suffer. This can result in high levels of perceived performance relative to customer expectations, and high level of satisfaction (point A in Figure 3). If capability is low and the

level of services provided is high, profitability is likely to be high. This can result in low levels of perceived performance relative to expectations and a low level of satisfaction may ensue (point B in Figure 3).

The VPM framework can also be used to portray the tradeoffs between strategic and tactical planning concerns. The strategic alignment is concerned with correct alignment of beginning investment in the incubator (e.g., space and facilities' capabilities) with the expectations of target tenant-customers. Both are long-term concerns for incubator management and must be viewed vertically. The fine tuning of capacity utilization with perceived ISP is a tactical dimension of primary concern to incubator management. Here a careful monitoring of day-to-day operations is necessary for horizontal alignment of the levels of service provided to short-term shifts in demand. The need to possibly rent more space and enlarge existing capabilities is a strategic decision, which must take into account tenant-customer needs and expectations. That largely means shifting from point B, Figure 3 upwards towards point A.) The reader can easily complete the example and see how incubator management must deal with customer dissatisfaction on a tactical level. A move from point A, Figure 3 down to the right, point B. Understanding of the VPM framework can be enhanced with a case study of business incubators as they try to stimulate business incubation.

SOME VPM IMPLICATIONS

Strategic aspects and factors contributing to establishing business incubators include funding and initial capabilities levels. These depend on collaboration among, and support by, communities and organizations involved in establishing incubators. The severity and perceived political and economic fallout from adverse local economic conditions are another factor. Negotiations for and the garnering of resources are the antecedents of the capability side of the ISP triangle (Figure 2). This includes buildings, location, facilities, budgets and other services – all of which must be customized for the potential tenants. Location and facilities are an important strategic decision. The need to revive deserted factory buildings, an old marketplace, a dilapidated central business district determines ISP, yet is often made with little attention to potential TCS and often overrides considerations of TCS. In that case VPM outcome – success in incubation may suffer.

Good strategic decisions directly impact the capacity side of the ISP triangle (Figure 2), and through that the TCS. Suitability of the space and communication conduits affects TCS. The capacity utilization is often impacted by the flexibility of reallocating available space to new or growing tenant customers. The number of square feet available to rent is viewed as the most critical capability factor in terms of its impact on capacity utilization and ISP and is a key metric used to describe and measure incubators. Summarily investments in capability are strategic in nature and must largely be completed before any tenants enter the facility.

Some authors (Hansen, et al, 2000) argue that of all the other services provided by incubators, the most important type of service is the ability to give start-ups preferential access to a network of potential partners. Many of these are a function of the operating budget, a capacity aspect of VPM. The impact of available capability and capacity utilization on TCS can be easily discerned by the reader, as location and facility factors impact expectations, while capacity utilization impacts perceived performance.

Current data on ISP include reports and measures such as: "In 2001 alone, North American incubators assisted more than 35,000 start-up companies that provided full-time employment for nearly 82,000 workers and generated annual earnings of more than $7 billion." (www.NBIA.org). The NBIA site further reports that business incubators have created successful companies and reduced the risk of investment. In the US alone, there are now approximately 960 business incubators who help reduce the risk of small business failures. That compares to 587 in 1998 and 12 in 1980. NBIA member incubators' longer term success is indicated by the survival rates of graduates: 87% of all firms that graduated from member incubators are still in business. 60% of business incubators are either self sufficient or could be self sufficient if subsidies ceased. In 1997, only 13 percent believed they could continue at current levels without subsidies. It is not clear if NBIA member incubators outperform nonmember incubator counterparts, (Sherman, 1999).

TCS perspective is only assessed indirectly by the length of time tenant customers stay in the incubator. Surveys and measures of tenant satisfaction are far less prevalent – yet need to be.

VPM IMPLICATIONS FOR INCUBATOR MANAGERS

Starting with market needs assessment, a location and staff must be selected. Development of strong sponsors, community support, and a 'champion/manager' for the incubator are crucial capability aspects. Since there are multiple stakeholders, the incubator manager must sort the conflicting demands, and allow the incubator to focus on incubating businesses and generating graduates, which in turn impacts both TCS and ISP. Some of the recommendations are:

A. Build management team with business experience – to improve ISP
B. Mobilize investments and working capital and develop seed/venture capital sources for tenants to improve TCS
C. Promote greater private sector participation – to improve capacity utilization and TCS
D. Create incubator 'brand' and image of success by enhancing partnerships (universities-research facilities, businesses, local associations, etc., to improve both ISP and TCS
E. Monitor and assess progress of tenants and towards self sufficiency and sustainability to improve overall VPM (both efficiency and effectiveness)
F. One-stop facility to receive counseling, training, and information, under one roof to improve VPM overall efficiency and effectiveness
G. Select entrepreneurial tenants with growth potential to improve VPM overall efficiency and effectiveness
H. In order for a 'brick and mortar' facility to maximize its space utilization it needs a stable of ready (and willing) potential tenants, providing the incubator with the most rental income, and a smooth transition for graduates to improve VPM overall efficiency and effectiveness. This can be facilitated with virtual incubators.

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A Small Company's Dilemma: How to Use Search Engines for Sales Effectively

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Introduction

Today it is imperative that all businesses, large and small, have an internet presence. With over 1 billion users in 2005 spending an estimated $143.2 billion in online sales, it can hardly be ignored. For many small businesses, developing an effective web site that allows online transactions or drives customers to a physical location is often the easy part. The difficulty is getting seen by potential customers, and companies want to do everything they can to track this information.

The key to being found by the right people at the right time lies with search engines. The two major internet search engines at this time are Google, Inc. and Yahoo, Inc. There are essentially two ways a customer will find a business site, through an organic or a pay-per-click listing.

The organic listing is generated at no cost to the business owner. The search engine generates a ranked listing of sites relevant to the key word used by the customer. The sites listed first are those deemed most relevant by the search engine based on factors like site content, links, and current updates. Typically the organic listings are the bulk of the copy on the screen, and each search engine has their own algorithm for ranking the list of sites. And indeed this algorithm can often change.

Pay-per-click advertisements are listed on the side, usually shaded or noted as "sponsored" links so that a customer will understand that the link was purchased by the web site business. This purchased listing, is dichotomous to a listing that is organically ranked, and it puts forth a different message to the customer, not necessarily a negative message, but certainly different. The price paid per click is determined on an auction basis. For example, if a business wants the top spot for the term "gold ring", they will bid up to a certain amount "per click". Whenever the search engine displays an advertisement for a business web listing and a customer clicks on it, that action leads the customer to the business web site, the company is charged an amount of money by the search engine company. Since this charge occurs each time a customer clicks through to a business web site and since this cost is changed regularly on an auction basis, then it is obvious that this can be an expensive process, especially to a small company. The question is then, is this cost necessary to the business, or is the organic listing just as productive to the small business.

Conversion rates are critical to small businesses. The definition of a "conversion" will be different for different businesses. It may be an online purchase, or a catalog request, a phone call, whatever the 'call to action" of the web site is. When a potential customer enters the term "gold ring" on a search engine and sees a pay-per-click advertising listed on the right side of the screen, the customer knows that a fee for the copy was required, although it is not a direct cost to them. If they are interested based on the copy of the ad, they will "click through" to the web site

page of the manufacturer. If they are satisfied, they will purchase the product off the web site (or call the company for larger orders). This purchase is called the "conversion" to a sale.

To make a pay-per-click campaign effective, companies spend significant time identifying the best keywords and trying to control the cost per click. Auctions are done daily, but one can look back historically to determine the cost of a first place ranking versus that of second or third. Therefore companies must continually review this information, which is quite time consuming, especially to the smaller company with a small office staff.

This paper will examine the issues of pay-per-click marketing, click-throughs to the web site, and conversions on the web site for a small to medium sized company. The small company needs to balance the pay per click cost of doing business and the advantage of obtaining a conversion to a sale.

The Choice of Search Engines

As noted in the *Economist* newspaper, Google currently dominates the web search market, but rival companies are entering this very lucrative market. Indeed, today people even use the terminology "google" as a verb in place of the word to search. Google has an American market share of 43% as of April, 2006. That percentage climbs to 50% if one counts in AOL, an internet property that uses Google's search engine. Furthermore, Google's market shares grew by 17% in the last four quarters to the spring of 2006. (Economist, 2006)

Yahoo, the world's largest internet portal with about 400 million users, actually lost some shares last year, but it does control 28% of the search engine market. MSN, which belongs to Microsoft, has 13% of the market, and Ask.com currently has 6%, but is growing at a very fast pace. There are other smaller companies as well, such as Clusty.com or SNAP.com, but at this time they do not compare to the 4 big ones. These 4 companies are competing in a fierce market, and since consumers can change their choice at any time, in fact change is simply a different click, then the leadership of the top 4 can always be in question. (*Economist,* 2006) Each company has their own algorithm for performing a search, and that algorithm is frequently reviewed. Google's algorithm often returns far too many web site listings to the search question. Others rank the web sites by incoming links to customers' personal preferences by using metadata, which customizes a bit, but this algorithm could ignore a potentially important web site.

In May, 2006, Yahoo announced an alliance with eBay, Inc. Yahoo will exclusively sell search and graphical advertising on eBay. EBay will allow Yahoo to use the commission based PayPal payment service, used to transfer money on the Yahoo site. EBay will also get a percentage of the revenue generated by Yahoo advertisements. This "co-option" is changing the internet industry, and experts feel that we can expect to see more of this merging. As eBay uses the Yahoo search engine, a customer will receive information on the item in question, such as "shoes". After the search, Yahoo will also send the customer information on related items, such as socks. (Kopytoff, 2006) This is an example of how metadata can be used. The technology will also allow a customer to click on an icon and call an advertiser before making a purchase. Thus customer to company relationships will be easy to establish.

The Problem

Smaller companies are always concerned with how to control time versus cost. At first glance, it appears that the pay-per-click option would be very productive for small businesses. Although it can be costly, sometimes it is the only way a company's web site will be seen by customers. Also it is difficult for small companies to compete with the giants in the organic click venue, because in the organic stream, the larger companies will generally land on top of the list. For example, a small manufacturer of gold jewelry will probably not get top billing over Tiffany's on the organic list.

Not only do companies have to consider the cost of the pay-per-click, but companies must also review search engines, indeed on a weekly if not daily basis, to ensure that the search engines employed do land the company on one of the top spots of the list. This review must be done by an in-house analyst or by an outside consultant. The in-house analysis would take valuable time away from someone in the company who has many other duties and who may not be educated about how the search engine market operates, especially since the search algorithms often can change. Hiring an outside consultant is an option, but it is another cost that the small company would like to minimize.

Conversely with the organic listing, companies have minimal control whether their web page listing would appear on the organic list generated by a search engine. In fact the only control the company would have is to implement exceptionally good keywords, but every company is doing that. If a company gets a free listing, but that company is the 200^{th} name on a rather long list, this procedure does not particularly generate a large number of sales. Therefore, if a company is serious about search engines finding and listing their web site toward the top of the list, then they will choose to accept the large and somewhat uncontrollable cost of the pay-per-click linkage. Or will they?

Ultimately companies want to track how many conversions from a click-through actually result in a sale, but the tracking is not always transparent. When a company receives a sale on-line, management can only refer back to the previous electronic page from wherever the sale came. Thus if the click-through came from a search engine, the company can track that the sale came from the designated engine. But often, savvy internet customers surf and search the internet, using bookmarks to hold a reference. If a customer returns to a bookmark, and then a sale occurs, the company cannot track from which engine or which venue, organic or pay-per-click, the sale came. Getting correct data can often be a daunting and time consuming task.

An Example of a Small Company's Dilemma

Kennedy Incorporated is a medium size manufacturing corporation in Rhode Island that makes incentive items for other businesses. The company owners would like to know if using the organic listing is just as profitable to their business as using a pay-per-click venue. Originally, they believed that the pay-per-click method would give them more visibility, but now they are not so sure. If they choose to use a pay-per-click method, then the second question is whether to use Google, Yahoo, or another engine. Some data can be tracked, but it is not easily deciphered,

and small companies that usually have a small management staff cannot afford the time it takes to constantly review the ever changing data.

In examining the pay-per-click method, the management first wanted to know what keyword phrases to pick and what would be the cost per click of those phrases to insure them a position at the top of the sponsored list. Looking back historically, the data from one particular month showed that the variance of cost for position on the sponsored list changed quite a bit from keyword to keyword. See table 1. For example, the "key chain promotional product" had a click cost of $2.73 for first place on the sponsored list, but dropped dramatically to a cost of $0.15 for the second position bid. That is a huge cost differential for simply being listed second on the sponsored list. However that key word only received 126 search requests, so being second or third on the list would appear to be good enough. All the key words that received search requests in the thousands had fairly small differentials from first to second bid and often even to third bid. The problem is that the management would need to review each key word individually and frequently.

Table 1

Keyword List	**Position Bids**			
Relevant Keywords & Phrases	1	2	3	Search Requests
Corporate Gift Promotional Item	2.39	2.36	1.33	254
Corporate Logo Gift	2.76	2.75	1	763
Custom ID Tag	0.86	0.8	0.45	76
Custom Key Chain	1.12	1.11	1.07	1,406
Custom Key Tag	3	1.01	1	388
Engraved Corporate Gift	1.5	0.85	0.84	335
Key Chain Manufacturer	0.52	0.51	0.51	272
Key Chain Promotional Product	2.73	0.15	0.1	126
Key Ring	0.56	0.55	0.51	4,384
Key Ring Manufacturer	0.6	0.3	0.26	72
Metal Key Ring	0.24	0.16	0.15	99
Personalized Engraved Corporate Gift	0.22	0.2	0.2	1,091
Promotional Key Chain	1.77	1.76	1.46	1,359
Promotional Key Chain Item	2.74	2.73	2.36	463
Promotional Key Ring	2.74	2.73	1.5	114
Promotional Key Tag	0.81	0.8	0.61	274
Wholesale Key Chain	0.41	0.4	0.35	753
Wholesale Key Ring	0.41	0.4	0.39	102
Wholesale Novelty Key Chain	0.19	0.16	0.15	28
Trailer Hitch Cover	0.82	0.81	0.4	4,928
Trailer Hitch Receiver Cover	0.82	0.29	0.28	71
Bookmark Wedding Favor	0.25	0.16	0.15	416
Bookmark Custom	0.82	0.75	0.34	393
Bookmark Metal	0.22	0.1	0.1	231
Bookmark Engraved	0.21	0.1	0.05	186

Once the company decides on key word phrases to use, then they would like to compare the cost of search engines. They decided to look at data from Google and Yahoo, believing that most business would be generated from the two largest engines. One month of data from August, 2006 is captured in Table 2 and Table 3.

Table 2:

Pay Per Click Campaign Results			**Aug-06**			**Yahoo**
Keyword	Impressions	Clicks	CTR	Avg CPC	Cost	Avg Position	Convers
Corporate Gift Promotional Item	64	1	1.60%	$0.51	$0.51	4	
Corporate Logo Gift	332	2	0.60%	$1.01	$2.03	5	
Custom Key Chain	683	68	10.00%	$1.08	$73.58	2	
Custom Key Fob	2	0	0.00%	$0.00	$0.00	7	
Engraved Corporate Gift	87	0	0.00%	$0.00	$0.00	5	
Key Chain Manufacturer	104	5	4.80%	$0.45	$2.26	3	
Key Chain Promotional Product	14	0	0.00%	$0.00	$0.00	3	
Key Fob	1,534	35	2.30%	$0.40	$14.17	2	
Key Fob Manufacturer	3	0	0.00%	$0.00	$0.00	3	
Key Ring Manufacturer	37	2	5.40%	$0.44	$0.88	2	
Leather Key Fob	105	5	4.80%	$0.54	$2.70	3	
Leather Key Ring	44	1	2.30%	$0.41	$0.41	3	
Personalized Engraved Corporate Gift	58	0	0.00%	$0.00	$0.00	2	
Promotional Key Chain	745	28	3.80%	$1.56	$43.85	2	
Promotional Key Chain Item	366	0	0.00%	$0.00	$0.00	2	
Promotional Key Fob	2	0	0.00%	$0.00	$0.00	2	
Promotional Key Ring	47	1	2.10%	$0.28	$0.28	3	
Promotional Key Tag	65	1	1.50%	$0.86	$0.86	3	
Wholesale Key Chain	345	22	6.40%	$0.39	$8.65	2	
Wholesale Key Fob	2	1	50.00%	$0.10	$0.10	2	
Wholesale Key Ring	38	7	18.40%	$0.35	$2.50	2	
wholesale Novelty Key Chain	17	1	5.90%	$0.20	$0.20	4	
TOTAL	**4,694**	**180**	**3.83%**	**$0.85**	**$152.98**	**2**	

Table 3:

Pay Per Click Campaign Results			**Aug-06**			**GOOGL**
Keyword	Impressions	Clicks	CTR	Avg CPC	Cost	Avg Position	Convers
Corporate Gift Promotional Item	3	0	0%	$0.00	$0.00	7.7	
Corporate Logo Gift	16	0	0%	$0.00	$0.00	13.8	
Corporate Logo Gifts	28	0	0%	$0.00	$0.00	6.7	
Custom Key Chain	214	9	4.21%	$1.59	$14.29	6.8	
Cusotm Key Chains	104	1	0.96%	$2.26	$2.26	6.5	
Custom Key Fob	10	0	0%	$0.00	$0.00	1.3	
Custom Key Fobs	8	1	12.50%	$2.19	$2.19	1.4	
Engraved Corporate Gift	4	0	0%	$0.00	$0.00	31.5	
Engraved Corporate Gifts	7	0	0%	$0.00	$0.00	4.6	
Key Chain Manufacturer	6	0	0%	$0.00	$0.00	3.7	
key Chain Manufacturers	7	0	0%	$0.00	$0.00	4.9	
Key Fob	906	9	0.99%	$0.71	$6.39	2.9	
Key Fob Manufacturer	1	0	0%	$0.00	$0.00	1	
Key Fobs	423	13	3.07%	$1.43	$18.61	3.6	
Key Ring Manufacturer	9	0	0%	$0.00	$0.00	6.3	
Key Ring Manufacturers	3	0	0%	$0.00	$0.00	2.3	
Key Rings	1	0	0%	$0.00	$0.00	2	
Leather Key Chain	85	3	3.53%	$0.89	$2.67	6.4	
Leather Key Chains	16	1	6.25%	$0.40	$0.40	3.1	
Leather Key Fob	767	2	0.26%	$0.62	$1.25	1.1	
Leather Key Fobs	18	2	11.11%	$1.61	$3.22	1.3	
Leather Key Ring	41	0	0%	$0.00	$0.00	3.9	
Leather Key Rings	18	1	5.56%	$0.36	$0.36	2.7	
Personalized Engraved Corporate Gift	3	0	0%	$0.00	$0.00	9.3	
Promotional Key Chain	142	2	1.41%	$2.48	$4.96	4.9	
Promotional Key Chain Items	6	0	0%	$0.00	$0.00	5.7	
Promotional Key Chains	86	0	0%	$0.00	$0.00	11.4	
Promotional Key Fobs	2	0	0%	$0.00	$0.00	3.5	
Promotional Key Ring	11	0	0%	$0.00	$0.00	7.1	
Promotional Key Rings	127	12	9.45%	$2.02	$24.21	4.8	
Promotional Key Tag	4	0	0%	$0.00	$0.00	10	
Promotional Key Tags	6	0	0%	$0.00	$0.00	5.5	
Wholesale Key Chain	53	5	9.43%	$1.42	$7.12	3.2	
Wholesale Key Chains	77	1	1.30%	$2.38	$2.38	7.4	
Wholesale Key Fob	1	0	0%	$0.00	$0.00	1	
Wholesale Key Fobs	2	0	0%	$0.00	$0.00	1	
Wholesale Key Ring	19	2	10.53%	$1.06	$2.11	3.2	
Wholesale Key Rings	29	4	13.79%	$1.28	$5.10	4.9	
TOTAL	**17,082**	**109**	**0.64%**	**$1.40**	**$152.18**	**2.8**	

Notice that the total costs were almost the same, although Google requires that plural words are listed as separate keywords, which really complicates the issue even more. The average cost per click (CPC) was higher with Google. Notice for example that the click through rate (CTR) for

"Key Fob" with Yahoo was 2.30%, but "Key Fob" and "Key Fobs" with Google gave 0.99% and 3.07%, quite a variance between the two words.
Because of the use of plurals, Google had 17,082 total impressions compared to Yahoo with only 4,964, but the overall CTR was quite low for Google at 0.64% compared to the CTR of 3.83% for Yahoo. Also remarkable was the fact that Yahoo and Google had very similar total average positions, although Google had a significant variance of average positions as listed in the table and compared to Yahoo's average position data.

Further Research and Conclusion

The smaller companies in particular need to be aware of this variant cost, and it behooves them to analyze the cost of the search engines and if the search engines are returning conversion sales to the company. Notice that Table 2 and 3 show no conversions for any of the key words. That simply means that the conversions did not occur immediately after the click through from the Yahoo or Google web page. The management of Kennedy Incorporated has the "gut feeling" that Yahoo is a better search engine for them, and they also feel that the organic listing is just as productive for them as the pay-per-click venue. Extensions of this paper will include data further data from Kennedy Incorporated and other small to medium size companies. Interesting questions include whether, in business to business dealings, is one search engine better than another? Also are pay-per click venues always the best way to advertise a product so that a conversion to a sale is made?

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RECONFIRMING EXCELLENCE IN SERVICE DELIVERY: THE CHALLENGES FACING SERVICE PROVIDERS FIGHTING INVISIBLE EXCELLENCE

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ABSTRACT

Service providers who perform at a very high level are faced with the unique challenge of having their customers get to a point where it is possible that they take service excellence for granted. These service providers must devise a marketing strategy that will remind their customers of the value they continue to receive once what was once perceived as outstanding service has become routine. The results of a qualitative study on marketing service excellence will be presented.

INTRODUCTION

Is it actually possible for great performance to kill your service business? If you are inclined to agree with Mosby and Weissman (2005) it certainly can or at least create problems for which many service providers are not prepared. Like most organizations, service providers are accustomed to the challenges of attracting new customers. There are, however, different challenges in maintaining the service value perceptions of repeat and long-standing customers

and service providers who are unable to meet these challenges may eventually face a disillusioned existing customer base. Over time, a level of service that was once considered outstanding or excellent may come to be viewed as merely satisfactory because the standard has been set so high. Excellence becomes both expected and invisible, leaving organizations struggling with how to reassure their long time customers that they are indeed continuing to receive outstanding service. While a great deal of research in the area of service marketing has focused on topics such as satisfaction (Oliver 1980), service quality (Parasuraman, Zeithaml, and Berry (1988), customer delight (Kumar and Iyer 2001; Kumar, Olshavsky and King 2001; Oliver, Rust, and Varki 1997) and other related issues, little attention has been given to maintaining and renewing perceptions of service excellence after a relationship with the customer has begun.

According to disconfirmation theory (Oliver 1980), prior to the initial service encounter it is important for the service provider to find a means to establish the customer's expectation of what will happen during that first encounter. These expectations will form the basis of the evaluation of the service provider's performance to determine whether the consumer is satisfied, dissatisfied, or, in the best of cases, delighted with the service. This first expectation can be influenced through many of the classic marketing methods of promotion. After the initial service encounter, however, the customer's prior experiences with the service provider will play a prominent role in the formation of any future expectations of that provider (Woodruff, Cadotte, and Jenkins 1983). Therefore, it is imperative that the provider consider the constantly changing customer expectations when formulating marketing strategies and tactics if an ongoing relationship with the customer is a company goal.

AVOIDING THE TRAP OF EXCELLENCE INVISIBILITY

While it is true that any one or combination of the factors discussed above can be salient to any service encounter, the service provider must know that the importance and impact of any one dimension can, and probably does, vary over time. Zeithaml, Bitner and Gremler (2006) propose that customers' expectations of service providers do change over time and can fluctuate according to the impact of marketing efforts and competition. It is also necessary, however, to consider prior experience as a potential factor in any such change. Mosby and Weissman (2005) posit that service excellence can become invisible to consumers over time and this invisibility can be at least in part attributed to the raised level of performance to which the customer has become accustomed. For example, if a customer is pleasantly surprised or delighted during early encounters with a given service provider, at some time they will come to expect the high level of service. The high level becomes the norm rather than a source of pleasure or delight. As this higher level of expectation becomes solidified, performance that was once perceived as excellence is now just as good but no longer noticed by the customer as special. The challenge to the service provider is now to remind the customer in an appropriate manner that they are receiving excellence. Even more problematic to the excellent service provider is that any failure to measure up to the elevated standards might seem to be a major failure where once it would never have been noticed.

THE STUDY

A qualitative study is being conducted. A series of 25 interviews is being conducted on the topic of excellence in services. Subjects are being asked about service excellence and the dimensions that they value most from the service providers they discuss. They are also asked about how

receptive they will be to any marketing efforts in which the service provider might engage aimed at reconfirming that the level of service being provided is truly exceptional. The results of these interviews will be discussed at the conference presentation.

References furnished upon request by J. Curran

EFFECTS OF ENVIRONMENTAL CONDITIONS ON BUSINESS SCHOOLS' INTENTIONS TO OFFER E-COMMERCE DEGREE PROGRAMS

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ABSTRACT

Innovation diffusion literature, due to certain volitional control assumption, focused more on intra-organizational factors to the detriment of inter-organizations environmental conditions. Recently however, that trend has been fortunately changing with Teo et al. (2003), who used institutional pressures to predict organizations' intentions to adopt inter-organizational linkages. In the current study, we tried to go beyond Teo et al. (2003) to use, in addition to institutional pressures, competitive pressures and resource dependence to investigate business schools' intentions to offer electronic commerce degree programs (ECDP). Preliminary results indicated that environmental conditions constitute significant determinants of sampled schools' intentions to offer ECDP.

INTRODUCTION

Background of the Research

E-Commerce is a new way of doing business that continues to expand rapidly worldwide. Since it began in the mid 1990s, E-Commerce has grown in the United States alone from "a standing start to a $172 billion retail business and a $1.5 trillion business-to-business juggernaut in 2005"

(Laudon and Traver, 2007). Beyond the USA, E-Commerce is growing also fast in Japan, China, Brazil, India, and Europe. Laudon and Traver (2007), therefore, predict that E-Commerce will eventually influence nearly all commerce, or that most commerce will take the form of Electronic Commerce by year 2050.

Purpose of the Research

Given the future prospects of E-Commerce, a question can be asked as to whether educational organizations intend to offer Electronic Commerce Degree Programs (ECDP). In the current paper, we tried to answer that question using established environmental theories: institutional, population ecology and resource dependence theories.

Concept of "Electronic Commerce" Defined

The concept "Electronic Commerce" has been defined in various ways in the literature. For example, Lawrence et al. (1998, p.2) defined electronic commerce as "the buying and selling of information, products and services via computer networks …, using any one of the myriad of networks that will make up the Internet." However, electronic commerce is not only about "buying and selling"; it is about a much wider phenomenon. Turban et al. (2000, p.5) introduced the word "exchanging" to include more activities under the scope of "E-Commerce." Further, researchers at the Australian National Office of Information Economy (1999, p.60) have argued that electronic commerce may include all intra-company and inter-company functions. This latter conception of "electronic commerce" is consistent with the broad and inclusive definition of the European Commission as "any form of business transaction in which the parties interact electronically rather than by physical exchanges or contacts." Thus, we use the concept "E-Commerce" to refer to any form of business transaction in which the parties interact electronically rather than by physical exchanges or contacts.

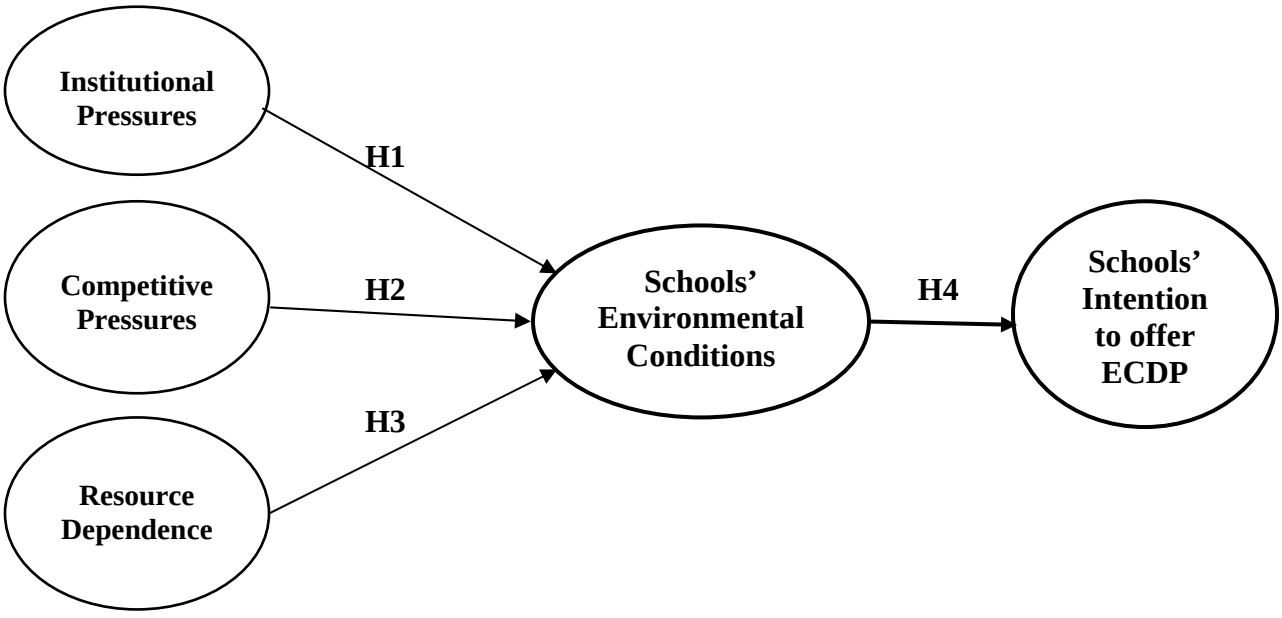
Concept of "Environment" Defined

There exist several types of environment: "task environment", "social environment" and "physical natural environment. The focus in this study is on organizations' task environment. The task environment is the environment in which organizations conduct their normal businesses. In other words, the task environment is the operation domain where an organization "draws the majority of its customers and in which the majority of the dealers it considers to be its competitors are located" (Achrol & Stern, 1988, p. 40). The social environment refers to the intra-organization climate in which people work together. The social environment is shaped by not only the people who work in the organization but also by the ergonomic aspect of the work place. The natural environment corresponds to the ecological environment, over which organizations do barely have control. In the current study, we use "environment" to refer only to the "task or business environment."

HYPOTHESES DEVELOPMENT

Research on organizations' intentions about innovations has been conducted essentially from intra-organizations behavioral perspective, using such theoretical frameworks like the theory of reasoned action (Fishbein and Ajzen, 1975), the diffusion of innovations (Rogers, 1983), the technology acceptance model (Davis, 1986), or the theory of planned behavior (Ajzen, 1985, 1991). Despite strong insights into the interplay between organizations and their environments (Lawrence and March, 1967; Thompson, 1967; Hannan and Freeman, 1977; Meyer and Rowan, 1977; Pfeffer and Salancik, 1978), the inter-organizations environmental perspective has been neglected for a long time. Only very few prior studies have used environmental theory-based variables to investigate organizations' intentions about innovations. Teo et al. (2003) utilized institutional factors to predict organizations' intentions to adopt inter-organizational linkages, while Berrett and Slack (1999) used both competitive and institutional pressures to investigate corporate sponsorship decisions. More recently, Renzulli (2005) investigated the emergence of charter schools in the United States with several environment-based variables; however, he used secondary rather than primary data. This study extends on one hand Berrets and Slack (1999) and Teo et al. (2003) by using three environmental theory-based variables (institutional pressures, competitive pressures, and resource dependence) to investigate business schools' intentions to offer Electronic Commerce Degree Program in the United States. On the other hand, it complements Renzulli (2005) by using primary survey data rather than secondary convenient data. The postulated research model is presented below in Figure 1.

Figure 1: Hypothesized Model



Institutional Pressures and Environmental Conditions

Institutional theorists (Meyer and Rowan, 1977; DiMaggio and Powell, 1983; Oliver, 1991) postulated that organizations are constrained by external non-competitive factors (social rules, taken-for-granted conventions, norms and practices) that subject them to important institutional pressures. Consistently, we formulate the study's first hypothesis as follows:

Hypothesis 1: *Institutional pressures will have an impact on a business school's perceived "environmental conditions."*

Competitive Pressures and Environmental conditions

It is generally agreed that competitive pressures exert some impact on organizations' decision making. Kimberly and Evanisko (1981) argued that competition between firms within the same industry is one of the major environmental factors influencing their decisions to adopt innovations. Porter (1980), population ecologists (Hannan and Freeman, 1977) and Oliver (1991) recognized as well the effects of competitive factors. Bain (1956) suggested that the impact of competition on organizations is particularly observable in highly concentrated organizational populations. Thus, we formulated the following hypothesis:

Hypothesis 2: *Competitive pressures will impact on a business school's perceived "environmental conditions."*

Resource Dependence and Environmental Conditions

According to resource dependence theorists (Pfeffer & Salacik, 1978), organizations are constrained by others who have ownership and/or control needed resources. Therefore organizations' decisions making is generally influenced by dependence on providers of resources. Bigelow and Stone (1995) and Schumaker (2002) have previously tested the effects of resource dependence of organizations' decisions making. Following them, we expect that resources dependence will determine "environmental conditions", which will then predict organizations' intentions to act in response to an innovation. Consistently, we posit:

Hypothesis 3: *Resource dependence will impact on a business school's perceived "environmental conditions."*

Environmental Conditions and Intention

Environmental conditions within an organizational population generally affect the intention of individual organization to respond to an innovation. The more favorable are the conditions in the environment, the greater should be the likelihood that organizations be willing to respond to an innovation taking place in their organizational population. Consistently, we posit that:

Hypothesis 4: *Environmental conditions will impact on Business schools' intention to offer electronic degree programs.*

METHODOLOGY & RESULTS

We collected data from a random sample of business schools using a web-based survey method. The survey was posted on the secure server of our university. Potential respondents visiting the survey web site could decide to proceed to complete the questionnaire or to exit. In September 2006, we sent 1156 emails to potential respondents, from which we obtained data about 110 schools, or an overall response rate of 10.52% of the valid targeted population.

Measurement Model

As shown in Figure 1, the postulated model has five constructs, which have been measured in this study: behavioral intention to act, environmental conditions, institutional pressures to act, competitive pressures to act and resource dependence. The reliabilities of the study's constructs were all above the 0.70 threshold (Nunnally, 1978), which suggests that there was a good internal consistency among the items that comprised the study's constructs.

Results for the Structural Equations

On the basis of the measurement results, we carried out the analysis of the structural model and tested the postulated hypotheses. All hypothesized paths were significant. In addition to the original hypotheses, we found a strong significant path between resource dependence and schools' behavioral intentions and a weak but significant path between competitive pressures and the outcome variable.

DISCUSSIONS

The overall goodness of fit of the postulated model was reasonable despite a significant Chi-Square, due probably to adverse influences of insufficient sample on model specification. Root Mean Square Error of Approximation (RMSEA) was 0.074, within the reasonable model fit range (Browne and Cudeck, 1992; Hair et al., 1998). Corroborating the reasonable model fit was the 90% confidence interval of the RMSEA, [0.04; 0.11], which fairly fell under the 0.10 ceiling. In addition to the RMSEA, alternative fit statistics were above or very close to the 0.90 threshold (Normed Fit Index = 0.89; Comparative Fit Index = 0.95; Incremental Fit Index = 0.96, and Goodness of Fit Index = 0.92). Thus, it was permissible to rely on the postulated model to interpret and discuss the results for the study's hypotheses.

Institutional Pressures: The study's first hypothesis suggested that "*Institutional pressures will determine a business school's perceived "environmental conditions."* This hypothesis was supported because the path between "institutional pressures" and "environmental conditions" was significant. Further, "environmental conditions" mediated to some extent the relationship between "institutional pressures" and "intention to act."

Competitive Pressures: The study's second hypothesis has stated: *"competitive pressures will determine a business school's perceived "environmental conditions."* This hypothesis was supported, as indicated by the significant path between "competitive pressures" and

"environmental conditions." In addition, "environmental conditions" did mediate the relationship between "competitive pressures" and "intention to act."

Resources Dependence: The study's third hypothesis posited that: *"Resources dependence will determine a business school's perceived environmental conditions."* This hypothesis was not supported, as its path to "environmental conditions" failed to be significant. In contrast, the path between resource dependence and intentions to act was strongly significant ($\beta = 0.65$). The strong direct effect of resource dependence on "intention to act" suggests that resource dependence may potentially have unique effect on "intentions to act."

Environmental conditions: The path between "environmental conditions" and "intentions to act" was significant, which constitutes a support for the study's fourth and final hypothesis.

CONCLUSION

To conclude, our study has contributed to the debate on organizations' agency, by enhancing our knowledge of some effects of environmental factors on business schools' intentions to offer E-Commerce degree programs. The results provide evidences to indicate that environmental conditions influence business schools' intentions to offer electronic commerce degree programs. Consequently, future research may pay more attention to the interplay between inter-organizations environmental conditions and organizations' intentions about innovations.

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INSTITUTIONALIZED CONSUMERS: CONSUMER BEHAVIOR BY PRISONERS AT (FICTIONAL) OSWALD STATE PENITENTIARY[1]

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ABSTRACT

Behind most every human behavior are motives reflecting fundamental, personal needs. These specific needs may vary depending on one's origins, culture, and priorities. Either way, behavior is universally motivated by the growing intensity of needs (Carver and Scheier 2005). This study focuses specifically on the realistic behaviors portrayed by characters in the Home Box Office prison series, Oz. Rose and Wood (2005) suggest that much insight into human behavior can be gained through the examination of such fictional representations. Through extensive viewing of the first and the final seasons of the series, consumer behavior by prisoners can be broken down into one of five common categories, four of them based upon Murray's Human Needs Theory (Costa and McRae 1988). The categories of consumer behavior at Oz, and seen in other studies of institutionalized consumers (Ozanne, Hill and Wright 1998), are: pursuit of power, group affiliation, hedonic consumption, and self preservation. The final, character-specific category refers to sporadic and idiosyncratic behavior seen on the part of specific characters. This study also examines reference group behavior and its affect on individual consumption. Additionally, the informal economy present in this fictional prison is examined.

INTRODUCTION

The HBO series Oz focuses on inmates within the confines of the experimental communal unit called Emerald City within the fictional Oswald State Maximum Security Prison, a.k.a. Oz. Emerald City inmates were given more privileges than average maximum security prisoners; however, if they abused these advantages prisoners would find themselves alone, stripped of additional privileges in solitary confinement. Privileges included: wearing their own clothing, being allowed to work, and having access to a limited amount of television viewing. Klein (2003) shows that incarcerated individuals gain additional dignity by being allowed to choose their own fashion.

So although not completely true to life, advantages Emerald City prisoners had over actual max-security prisoners were not uncommon in lower security prisons around the country. Approximately 10.2% of America's prison population was being held in maximum security prison during the airing of Oz (Federal Bureau of Prisons).

METHOD

The characters portrayed by actors on the show were used as the sample group. As the creators of the show did a great deal of research prior to the writing of the show, these characters strongly resemble the type of individuals which can be found in an actual prison setting. Viewing fictional

[1] The authors gratefully acknowledge the financial support of the RWU Provost's Undergraduate Research Fund

consumer behavior, either on film or in television series has been shown to be valuable in gaining insight into actual consumption (c.f., Stephens and Hill 1994)

In order to best understand the consumer behavior of Oz inmates, the entire first and last (6^{th}) season of the series were viewed watched in their entirety. Notes were taken, outlining the consumer actions and possible motives behind said actions. Consumer actions included ideas such as drug commerce, status assertion, defense mentality, religious behavior, and the concept of group and how it affected consumer behavior.

RESULTS

Power Consumption. The human need for power is defined psychologically as the desire or need to impact other people, as in to be in a position of influence. Those in power are able to evolve to the highest possible level of comfort attainable in their specific social setting. The fact that power has limits, both physically and psychologically is also noteworthy. The same is true for prisoner leaders within Oz's Emerald City. No matter how much power they have amongst other prisoners, even the leaders must obey correctional officers or suffer the consequences.

Emerald City prisoners provided a variety of ways to consume prison power. One way was shown by Kareem Said, who entered the prison a pronounced Black Muslim leader. His legitimate, position, and reference power on the outside carried into prison; as soon as the minister arrived eager Muslims were waiting at the entrance to greet him.

Mafia leader, Nino Schibetta also held position power, as well as coercive power, on the outside which transferred over, as there were many other mobsters serving time. Although his power did not immediately spread beyond his soldiers, the additional respect for the leader was made evident through special meals made for him in the kitchen, access to food from his cell, and possibly the most valuable, the undying loyalty of his followers.

Schibbetta's power extended further as his outside connections allowed him access to drugs. To have a product (tangible/non-tangible) which others desire, is to gain some form of power or control over them. The many prisoners in Emerald City who used drugs depicted the sixty-five percent of jail inmates who reportedly go into jail already having had a prior drug addiction. These inmates are or become slaves to their addictions and therefore allow dealers to gain psychological, as well as tangible dominance over them. For instance, in episode three, drug dealer, Simon Adebisi, was able to convince a fellow inmate to murder an enemy in order to pay off his drug debt.

Not all power extended as far as the entire block, or even an entire group; sometimes power could be held over a single other individual. Such was the case when white, upper-class, ex-lawyer, Tobias Beecher entered Emerald City in episode one. Beecher lacked any sort of coercive strength over his peers, nor did he have any prior affiliations. When Aryan Brotherhood leader, Vern Schillinger, said a few kind words to the new convict, Beecher asked to move in to his cell for both company and what Murray would refer to as succorance. By the time Beecher realized Schillinger's cruel intentions it was too late to associate with anyone else. Schillinger had complete coercive control over the frightened and confused Beecher; Beecher's new role was referred to that of a "prag." Once this status was obtained, only the most notable and noticeable change in action and attitude could free someone.

As each gang leader felt no reason to show deference to other established leaders and as each group yearned for maximum decision power as well as respectful recognition, there was a constant power struggle at the heart of the *Oz* series.

Group Affiliation. The desire to be accepted is universal; without acceptance by a group of some sort of genus social anxiety and/or depression is likely. According to Maslow's Hierarchy of Needs, being affiliated is what we seek after satisfying our physiological and safety needs. (Green 2000) In Emerald City, becoming part of a gang was often the most effective way to satisfy the safety need as well as the social need. In Emerald City, one's gang became their friends and family. They would provide social opportunities and compassion as well as safety and aggression. Klein (2003) found similar needs for affiliation among concentration camp prisoners.

The familiar, informal relationship which was exemplified by each of the groups in Emerald City was made evident as prisoners barely acknowledged fellow group members upon meeting with each other. Also, group members felt at ease to talk about plans and secrets with each other in the confidence that the knowledge would not spread any further. For instance, when a Homeboy named Johnny Post murdered another inmate, he showed no signs of suspicion that fellow gang members would give him up.

As fellow gang members were considered to be like family, they offered compassion towards each other as needed. When Homeboy leader, Billy Keane, was not allowed to see his fiancé on the day of their wedding, the other Homeboys consoled him with encouraging words of what potential the future could hold and showered him with drugs (a sign of kindness and nurturance).

By affiliating into a group one was also much less likely to face a physical threat. This is not to say that gang members did not encounter hazardous situations, but like a school of fish, the theory of safety in numbers states that an individual is statistically less likely to encounter a mishap if part of a larger group. When seventeen-year-old Kenny Wangler entered Emerald City he had no prior connections and was threatened with the possibility of obtaining the "prag status," which was discussed earlier in the report. However, as a young, African-American, drug dealer and user, he was a prime candidate to join the Homeboys. Joining the gang, therefore, fulfilled Wangler's needs for safety and acceptance simultaneously.

The power to retaliate was seen as another key feature of the group. If a fellow gang member was murdered or assaulted, the group would make its goal to find the responsible parties and punish them. For instance, when the leader of the Homeboys discovered that an Italian had brutally beaten his brother the group arranged for a member to kill the guilty party in retribution. Although not full-proof in the long run, speedy revenge warns others to be more cautious.

By the manner in which group members each dressed, it was obviously important to prisoners that others recognized them as a part of their respected group. The Aryans, for instance, wore a great deal of black and leather clothing; the Muslims, on the other hand, dressed neatly and wore religious head caps called, taqiyahs. If another prisoner could successfully identify your group affiliation than you were less likely to bothered. Some inmates would go as far as to getting tattoos representative of their group so they could be identified in any circumstance.

Consumption for Pleasure. The consumption of pleasure is something each of us strives for everyday. Ideally, one would assume pleasure over monotony and agony every time; however, in prison this is

hardly an option. There are two types of pleasure which one can strive for; sentience, the seeking of physical pleasure and the seeking of a state of nirvana, or psychological pleasure. In a study done reported by Sample (2004), it became evident that people will go through pain in order to reach a pleasurable outcome. In Oz, each prisoner was cavity searched for illegal paraphernalia after family or friends came to visit. Therefore, as Kenny Wangler exemplified in episode four, in order to get such items past guards one had to swallow them. Once back in his cell, a prisoner would then attempt to safely remove the supplies from his body. This uncomfortable and physically dangerous exercise illustrated the length to which prisoners would go for pleasure.

Not all pleasure in Oz originated in tangible objects; mental pleasure was seen as also being fulfilling to the user. Some prisoners chose to fill the emptiness of their new lives with religion. No matter the religion of choice, (most practicing prisoners chose Christian or Muslim paths) inmates found a way to relieve the guilt in regards to their crime. Through discipline, religion was also able to save a plethora of prisoners from the drugs and violence which encompassed the prison. Prisoners who were able to find happiness through God were the only prisoners able to preserve semi-ordinary lifestyles.

Self Preservation. Instinctively, all living things exert effort in the attempt to preserve themselves. Humans will specifically avoid fear, loneliness, hate, and anxiety. Prison life introduces each of these concepts into inmates' lives. The manner in which these prisoners chose or were forced to deal or not deal with such circumstances would be a determinant in the comfort of their stay.

Upon entrance to Emerald City it was of utmost importance to be assertive in establishing a position for one's self and to show as little weakness as possible. Irish mobster, Ryan O'Reilly did just this; as Emerald City did not house any of his associates he was forced to make new connections. By providing useful (true and false) information to gang leaders and claiming everyone's sides individually, O'Reilly removed himself from potential danger. Tobias Beacher admitted to others his innocence and lack of knowledge about prison life without awareness of their intentions; the result, others established his (undesirable) role of "prag" for him.

As real weapons were in short supply, any items which could be used in a defensive/aggressive manner were collected by prisoners. This included newspaper, which could be layered and wrapped around the torso to provide protection from stabbing and metal objects, which could be filed down into makeshift knifes.

If a prisoner was unable to preserve their state of well being for an extended period of time they would either psychologically shut down or retaliate in a final attempt to regain their welfare. After one prisoner accidentally stabbed his friend he was locked up in salutary; the lonesomeness of being in twenty-four hour isolation, combined with the guilt of stabbing his friend lead to his eventual suicide. After being taken advantage of for the entire season, Beacher attacked his enslaver, severely injuring the man's eye and concurrently claiming his independence.

Reference Groups. Emerald City prisoners broke themselves into six distinct groups; non-affiliates were referred to as the "others." The six main groups consisted of the Homeboys (1), Latinos (2), Muslims (3), Catholics (4), Aryans (5), and the Italians (6). Joining a group entailed taking on their beliefs as well as their friends and enemies; a concept never questioned as often times a member would not want to leave his specific group.

In instances when an inmate would join a group for personal gain, he would be cast out. When it was established that new entry, Huseni Murshah, had joined the Muslims only to use their manpower for his own interests, leader Kareem Said disbarred the man and instructed the other Muslims to never again acknowledge his presence. When a group leader made a decree, it became law within the group. For members to not show deference to their leader would display great weakness as well as incompetence in the group's functionality.

Whatever a group's defense mechanism of choice, its members were expected to assist and defend affiliates in all situations. Any member's actions were looked at by outsiders as an action by the entire group regardless of the truth; therefore, without support from the entire group, another prisoner would again assume weakness.

With the exception of the group of "other prisoners", a great deal of peer pressure was made evident throughout the season by different groups. To be a Homeboy meant one would be pressured to use and sell drugs; being a Catholic or Muslim entailed rejecting substances and actions which would cloud your vision or affect your soul after death.

Vicarious Consumption of the Outside World. Prisoners were depicted as wishing they were on the outside or finding ways to satisfy their longings for freedom to consume through the experiences or activities of others. For example, when prisoner Tobias Beacher was paroled, his close friend Chris on the inside at first wished him well and wanted him to do all the things a free person should. This soon became an obsession for Chris and eventually led to jealousy for the friend's freedom. Brownlie and Horne (1999) found similar sorts of longing with their inmate informants, including a desire for better drugs, better sex, better television, and interactions with important loved ones.

Cornwell and Gabel (1995) noted similar behavior in their study of institutionalized consumers, which they called surrogate consumer usage. Three forms of surrogacy were: getting black market goods for resale, participating in restricted activities vicariously through viewing outside media, and having others do favors that they were unable or unwilling to do for themselves. This latter was a common theme in Oz. For example, on several occasions, prisoners assassinated other prisoners in order to be accepted by or protected by a rival gang.

The Informal Economy. In Oswald State Prison, like in all other prison systems, prisoners were not allowed to hold currency (prisoners are generally allowed to hold bank accounts, but only in Oz were they able to make transfers); therefore inmates were forced to use a bartering system, similar to those who attend the Burning Man Festival in the Nevada desert. In both cases there is a lack of formal marketing, but unlike the fair-trade communal economy at Burning Man, Emerald City transactions are based more on Tonnies' Gesellschaft theory that buyers and sellers relations are solely for the purpose of the exchange. Prisoners would exchange tangible items such as drugs, alcohol, cigarettes, (which were prohibited in Oz during episode 3) and personal belongings, as well as services which included doing another's chores, serving another his meal, sexually pleasing another, and committing violent acts. No matter the situation both parties goal was to gain on their transaction. (Kozinets 2002) The different values which prisoners attributed to different things allowed transactions to take place. For instance, when a prisoner could not pay O'Reilly for drugs he had purchased (on credit), O'Reilly allowed the man to do his laundry for two months as payment.

CONCLUSION

While incarcerated, prisoner consumption is masked from any major media marketing; therefore the basic economic principle of supply and demand governs any and all market action. Many prisoners were convinced that conventional society could not offer them the goods and services they felt necessary to better their lives. According to juvenile delinquent studies done, this state of mind is apparently taken by the kind of individuals that were present in Emerald City at a very young age. (Ozanne, Hill and Wright 1998) With this in mind, it is unlikely that prisoners similar to the majority of Emerald City prisoners, 24-45 and very set in their ways, will ever amend their ways without a major psychological change in their lives.

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CREPIDULA FORNICATA: A NUISANCE OR AN ETHNIC SPECIALTY

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ABSTRACT

Crepidula fornicata, otherwise known as the common slipper limpet can be found along the east coast of North America. These shellfish are particularly plentiful in the New England waters of Rhode Island. The challenge of introducing this shellfish as a commercial product lies in determining if it is easy to harvest and prepare for market, has evidence of consumption, and has potential for acceptance as restaurant quality shellfish or substitute for more expensive alternatives. The study used qualitative methods to examine fishermen, people of Azorean descent who were known to eat the shellfish, and representatives of the food trades.

BACKGROUND

The Slipper Limpet is a snail; the shell opening on the underside of this snail resembles an overturned boat. There is a flat shelf projecting halfway across the opening along the bottom section. Local fishermen of the region also refer to these shellfish as "deckers" or "stackers." Slipper Limpets live attached to a rock or to another shell. They earned the name "deckers" because they pile up on top of each other like a deck of cards. They do not move around to feed; they are filter feeders siphoning editable particles out of the water flowing around them. Slipper Limpets are often found in high concentrations in oyster and clam beds. They compete with other shellfish for the same food source and tend to dominate these shellfish beds. They are currently regarded as a nuisance with no visible commercial market.

Members of the local Azorean immigrant community and its Portuguese descendents have consumed the New England slipper limpet as a substituted for a shellfish harvested in the Azores known as the *Lappa*. The original *lappa* is the Key Hole limpet, which is a relative of the limpets found in New England. The *lappa* and the slipper limpet have very similar characteristics to one another. These characteristics and the early consumption traditions have influenced the Portuguese to call the slipper limpets of the New England waters, *lappas*.

Harvesting

The harvesting of slipper limpets is a chief factor in understanding the potential labor and risks to process and distribute slipper limpets. In the Azores alone, there exist about 900 fishermen who actually fish and about 3,000 other fish-related jobs. The various fisheries include tuna, swordfish, lobster, deep water longline, octopus, shrimp, squid, limpets, and various others. It has been found that the harvesting of limpets was high in the mid 1980s and peaked in 1984. The harvest crashed "due to a possible 'limpet disease' in the late 1980s and has never recovered [4]. This raises the concern that if the harvesting *lappas* has continuously declined in the Azores, precautions or management may need to be taken in the New England to ensure that this does occur among the slipper limpets.

Culture

Different cultures reacted to and exploited the slipper limpet differently. Limpets have been harvested and used as bait or fertilizer and were included in peoples' diets for centuries. They never received much notice in some of the mainstream populations, whereas in others, they were of great importance. Historically limpets were seen as famine food eaten only during times of emergency food shortage. They were also an important staple food for the poor because they were easy to obtain and they have twice the caloric value of oysters. They were also used for flat fish bait, but they were not thought of as an acceptable food for the middle or upper classes. Small, secluded markets for limpets exist such as the Azores and Hawaii, and there is market potential in many other locations.

Every different society has some type of culinary tradition with three categories of foods: the raw, the cooked and the rotted. "The cooked is a cultural transformation of the raw whereas the rotted is a natural transformation" [3]. Different cultures may argue about the boundaries of the three categories, for example the French love moldy "rotted" cheese. In some cases raw food is not accepted and, in other cases, food loses its appeal if it is cooked. Slipper limpets are an attractive dish when they are raw or cooked. Culinary origins for this family of shellfish can be traced back to the Azores and are prevalent in the Portuguese culture that consumes these limpets.

To understand a proper way to make a specific food or dish attractive to different people, Cheney et. al. indicate one must first observe their culture and build from that. Unfamiliar foods such as slipper limpets have to be introduced delicately and directed specifically towards the target market with consideration to their ethnic and food cultures. In the contemporary American culture, food is valued for its nutrition, quick simple dishes and the majority of Americans are willing to accept and adapt to new foods. By contrast, Latin cultures focus heavily of personal relationships and individualism in their foods and culture. This distinction between "low context" and "high context" cultures and the "utilitarian" and "hedonic" aspects of consumption may affect that adoption of a new food item.

Reaching the attention of individuals to purchase new foods can be strategically done through incorporating culture in promotion and advertising. Barthes proposes various themes of food advertising. One theme is how foods allow a person to feel like they are living in the days of the past. The article notes that "…food brings the memory of the soil into very contemporary life…" Furthermore it explains how food is an importance of remembering our past as in, "…food frequently carries a notion of representing the flavorful survival of an old rural society that is itself highly idealized." [1]. Association of foods to past or cultural traditions makes food more acceptable or desired in the eyes of the consumer.

Consumers

While humans are omnivores, which means that they are plant and meat eaters, individual food preferences are complex, especially in encounters and reactions to new and unusual foods. Distrust is a common reaction people have that is based on their up bringing, cultural traditions and beliefs. This seems to be a natural reaction to unfamiliar food [5]. Categorizing the slipper limpet as a culinary delicacy may encourage individuals to think more highly of this food item. If slipper limpets are looked at as a higher caliber of shellfish, it may be easier to introduce them to

the culinary society. This may be especially important in encouraging "an individual characteristic that appears to be of paramount importance in every encounter with new foods is the extent to which a consumer is a neo-philiac who embraces novel food items or a neo-phobic who avoids unknown foods" [5]. These two distinctions in human behavior need to be understood in order to be able to correctly present the slipper limpets to the target market.

METHOD

In-depth interviews were documented with audio recording, comprehensive notes, and photographs. These methods of data collection ensured that the maximum amount of information was gathered at each interview. This captured both the verbal and nonverbal elements of the conversations greatly enabling, the researchers to be more thorough during the interviews. The four researchers who participated in this study were divided into two groups of two. One group, as reported in this paper, examined the harvesting, cultural and consumer aspects of the study. The other group focused on the potential commercial and consumer market.

First we interviewed a local shell-fisherman from Westport, Massachusetts. He specialized in collecting shellfish for wholesale, concentrating mainly on clams. His interview was vital because it gave us a understanding about how to collect, cultivate, and distribute shellfish in the New England area. Subsequently, we interviewed a consumer of Portuguese decent who has consumed both slipper limpets from the New England waters and *lappas* from the Azorean waters. His interview provided a personal perspective on the differences between the two shellfish. Finally we met with the head chef of a local, notable restaurant known for its inventive cuisine. His interview helped place the slipper limpet in the context of other shellfish dishes.

RESULTS

Harvesting

One late afternoon in October we interviewed Mr. John Borden at his New England Style home in Westport, Massachusetts. Mr. Borden has been an active fisherman in the New England waters for over forty years. Even though he is a retired marine officer and commercial fisherman, he still goes out a few times a week to shellfish for himself and a local fish market.

Mr. Borden has speculated about the potential of slipper limpets. He and other fishermen would come across these shellfish when they were out clamming in eight to twelve feet of water. "It seems that they're mostly in clam beds. Sandy type bottoms they require a good flow of water over them. These guys…as a matter of fact there is one good shellfish bed where there kind of screwed up because you've got to dig through them to get to the quahogs. In some places they're very thick to get to the clams you have to dig and move them, dig and move them, dig and move them till you get down to the littlenecks". His fishermen friends would complain about the slipper limpets as being a nuisance they never thought to eat or try to harvest and sell them.

It was much easier for Mr. Borden to collect just the slipper limpets from the top of the sediment rather than to dig below and pull up both slipper limpets and clams. He has tried to see if anyone in the area would like to purchase slipper limpets because he explains "I go around and get clams and oysters and we get a lot of these slipper limpets mixed in that are totally under utilized". He

has found one Portuguese fish market that buys about a bushel of slipper limpets a week. He has hopes of slipper limpets catching on and becoming popular in the same way mussels did. “All you have to do is think back about mussels with all those thousands and thousands of bushels of mussels and how they would just shovel it over the side and how you go to a restaurant and there like 20 bucks a pot for them”.

Mr. Borden believes that there is a viable market for slipper limpets in the Portuguese community and that this shellfish will fit nicely into many other seafood dishes. He notes that Azorean *lappas* are shipped over to the states for holiday occasions. “The guy that sells them said that they are a delicacy and they ship them in at Christmas, they ship in a lot of them (referring to Azorean *lappas*) … they sell like hotcakes. They’re much pricier, I mean real pricy. But you also have a lot of shipping involved”. Even though these two shellfish are very closely related, the *lappas* always sell out quickly but fish markets have yet to offer the slipper limpet as a substitute during the rest of the year.

Mr. Borden has lived off the sea for the majority of his life and has knowledge of what tastes right with certain seafood products. He has already begun brainstorming on dishes for slipper limpets. His first thought was that the slipper limpets would have to be sold and cooked with the meat inside of the shell. This is because the slipper limpet has a rather unattractive tail that is hidden inside the shell. Once cooked the tail end shrinks and is more aesthetically pleasing. Some of the dishes Mr. Borden came up with for the slipper limpets mirrored ideas that the head chef at from a local restaurant suggested. Mr. Borden noted that “You could probably sprinkle them over spaghetti. I have made them, just about last week, I had them with linguini and white sauce with garlic and a little of this and that and it tasted fine. My next project I might make chowder; I never realized how good the broth was until about a week ago.”

Culture

Jose Pereira, a current resident of Bristol, RI, but a native of Faial, Azores provided a perspective on the Azorean and Portuguese culture. He has eaten both slipper limpets from the New England waters and *lappas* from the Azorean waters.

Around the age of 12 and living in Faial, Azores, Jose and his friends used to go down by the water and harvest *lappas*. They would get them in the ocean near the rocks and they would use a specific type of knife to scrap the *lappas* off the rock. Jose would easily bring home six pounds, but would get as much as he needed depended on how many people were eating. He has always caught the *lappas* and never purchased them. His mother would prepare the *lappas* in various ways, including keeping them raw, cooking them with rice or making a broth from them. Additionally, they were grilled, but this was mostly done to the larger *lappas*. Jose further explained that there are actually two different kinds of *lappas*; ones that are more chewy and tough, which came from deep water, and ones that were more tender that could be caught at low tide when the visibility of them remained above the water. Jose and his friends did not collect *lappas* from the deep water.

Aside from Azorean *lappas*, Jose has consumed slipper limpets from New England waters. When he resided in Bristol in the early 1970s he was told about the slipper limpers and how they were located in Tiverton, RI. Jose, his brother, and father-in-law would go to Tiverton and gather

them. His father-in-law would be the one to cook them and he prepared them in two different ways. One way was completely raw, but with a side of cornbread and wine. When eating the slipper limpet raw, Jose would use a knife to eject the meat out of the shell. The slipper limpets were also prepared with rice. His father-in-law would make this *lappa* and rice dish by first steaming the slipper limpets to get them out of their shell and then he would sautee them with onion, parsley, garlic, peppers. Water was then added to this mixture, brought to a boil and then the final ingredient of rice ways added. Once the rice was cooked the dish was ready to enjoy.

Jose further explained that when he first came to Bristol, many people ate slipper limpets, and he still knows some people who continue to consume them. All the people that he knows that consumes these slipper limpets are all of Portuguese descent.

It was found that slipper limpets of the New England waters and the *lappas* of the Azorean waters have various differences and similarities. Jose explained how the *lappas* of the Azores are saltier and the waters are cleaner, but the slipper limpets of New England are actually more tender. In the aspect of physically appearance, Jose explained how the Portuguese *lappas* do not have a tail and judging by the ones he has consumed, they are also much bigger in size.

Consumers

On November 12, 2006 we met with a head chef of a local restaurant. Chef Sai is know for his uniquely eclectic dishes and his blend of distinctive tastes and flavors. We provided the kitchen with ten pounds of slipper limpets to experiment with. During our visit Chef Sai examined the appearance, texture, smell and taste of the slipper limpets we provided him with. After observing the different characteristics of the slipper limpets he determined what ingredients would best complement this shellfish. Once the ingredients were established, the chef concocted a dish composed of slipper limpets, white wine, garlic, shallots and butter. This dish was light and delicate and accented the slipper limpets' distinctive taste and texture.

During careful observation of the slipper limpets, Chef Sai determined that the tail end of the slipper limpets will be unattractive to customers. Therefore he suggested that slipper limpets be served in one of two ways. Either cut off the tail end of the slipper limpets if it is served outside of the shell, or just simply cook and keep it in the shell when it is served to customers.

Through experiments in the chef's kitchen some realizations were made about the slipper limpets and their commercial potential. The first thing that was noticed before the cooking took place was the unique boat shape and contour of the shells. When the shells are turned upside down the bottom side is smooth and there is a slight cup formation. This scoop shape would be perfect to hold a thick sauce, stuffing, or toppings. Before, during and after cooking the slipper limpets it came to everyone's attention that the slipper limpets produced a good amount of liquid. If this liquid was boiled down a nice broth or stock could be made. The liquid itself could also be used as a clam juice substitute. Overall, this experience and experimentation shows that the slipper limpets have high potential in the consumer market in an environment where experimentation is accepted.

CONCLUSION

Many different avenues can be ventured upon to find the prefect target market and the best way to market these shellfish. Slipper limpets are a versatile food. They have the flavor and individualism to stand alone as a main course, an appetizer or be incorporated into many different dishes. Before, during and after cooking slipper limpets produce a good amount of liquid which can be boiled down into broth or stock. The liquid itself could also be used as a clam juice substitute. Yet, it gives off a stronger flavor than clam juice, so a lesser amount would be required in recipes.

Throughout our studies some people have been skeptical about the commercial viability of slipper limpets but we believe these shellfish delicacies have the potential to fill a niche in seafood market. If expressed to the public correctly, people will embrace this new shellfish and a demand for *Crepidula fornicata* will result in vastly increasing commercial and restaurant sales.

Enticing the neo-philiac consumers to try the slipper limpet will direct the marketing to portray the limpet as a new, unusual, seafood treat. Neo-phobic consumers might not be able to be persuaded by early marketing schemes. Time is what it will take for them to be willing to try limpets. One way to encourage neo-phobic consumers to purchase slipper limpets is to provide dishes that appear on menus consistently so they become familiar with the name and by popular word of mouth. After constant repetitiveness neo-phobic eaters will let their guard down and begin to try and enjoy these shellfish.

Peasant cooking has been making a dramatic revival in many restaurant dishes. Therefore, this shellfish and its recipes could become commercially important in the years to come. Recipes including limpets have been published in Scottish cookbooks; in Hawaii they are considered a delicacy and the Azores highly value them in their cultural dishes. The limpets from the Azores and New England are very closely related but, the *lappas* that are transported from the Azores sell out quickly, whereas the slipper limpets collected from New England do not have a definite consumer market and no real market demand. Culturally sensitive marketing procedures have to be done to raise awareness, knowledge, and desire for the New England slipper limpet.

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CREPIDULA FORNICATA: A CULINARY DELICACY AND A CULTURAL REVIVAL

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ABSTRACT

Crepidula fornicata, otherwise known as the common slipper limpet – or, by fisherman as *deckers* –can be found along the East Coast of North America. While biologists believe that these shellfish are good candidates for aquaculture, others are skeptical about their commercial viability. This paper presents the preliminary results of a marketing study to assess whether there is a commercially viable market for *Crepidula*.

THE STUDY

A complete marketing assessment involves an investigation of both the production and consumption of *Crepidula*. At the production end of the spectrum, the relevant players include fishermen, wholesale fishmongers and shellfish distributors. Fish retailers, chefs and consumers inhabit the consumption end. These were our interview targets for this research. Though found along the Eastern seaboard of the U.S., at present *Crepidula* are almost solely consumed by the Portuguese community. Thus we interviewed a chef and a fish retailer to begin to assess the likelihood of consumption spreading to the broader population.

BACKGROUND

Slipper Limpets are filter-feeders that, in our local waters, are found mostly in oyster beds. The Limpets do not harm oysters, but they do compete for the same food. Further, because Limpets attach themselves to other shells, stacking one on top of another (hence the term "deckers"), they also make the harvesting oysters more difficult. Accordingly, most local fishermen consider Limpets to be a nuisance that inhibits their efficient harvesting of more desirable—and more lucrative—species.

Shellfish, of course, are not foreign to most Americans. The Slipper Limpet, however, does not look anything like commonly consumed shellfish such as mussels, clams and oysters. Instead, it resembles an overturned boat with a flat shelf projecting halfway across the open bottom. Further, it comes out of the water covered with a hairy, mossy coating. Both these features make it not only different from what consumers are accustomed to, but also unappealing.

Our task then was to find a way to make this ugly duckling of the shellfish world interesting to fishermen, to fish retailers, and to chefs – with the hope that eventually consumers could be enticed to try, and eventually, like Slipper Limpets.

LITERATURE REVIEW AND RESEARCH FOCI

Food consumption cannot be divorced from the culture in which is takes place. This would seem to be especially true when trying to introduce a new food. As Wansink, Sonka & Cheney so succinctly put it, "It is unwise to take a product, blindly introduce it into a culture, and expect it to do well" [6]. Instead, a food marketer needs to identify the likely opinion leaders, and begin the work with them. Chefs and their suppliers would seem to be a logical point of departure for *Crepidula fornicada*.

First explicated by Everett Rogers, diffusion theory addresses how an idea – or a product – makes its way from being introduced as something new, to being accepted by a larger section of society [3]. Critical to successful adoption is the role of opinion leaders – the people to whom the rest of us look for advice and guidance. In the food category, there are a number of opinion leaders – taste makers, if you will. We decided to focus our research on one of those: chefs. The father of modern gastronomy, Escoffier (1846-1935), set the pattern. According to Rossant, he "sent out over 2,000 chefs he had trained to promote French food and French products around the world" [4]. In the US today, chefs have an impact on what we consume, on the new foods we are willing to try.

The world of the kitchen also provides the appropriate language that could be used in discussing the Slipper Limpet. We took inspiration from the work of Claude Levi-Strauss who suggested that cooking is a language [2]. We needed to determine how to talk about the product to enhance adoption – and what sorts of discourse to avoid that might hinder that adoption. Chefs, of course, cannot operate restaurants without a reliable supply of products, Thus, food retailers play an important role in determining what we eat – simply because if a given food is not readily available, chefs cannot feature it on the menu. Thus, learning to speak *Crepidula* would likely take us into the language of cooking and the investigation of cultural foodways.

METHODOLOGY

A team of two researchers with marketing backgrounds developed and practiced interview protocols. We began with our own investigation by shucking and consuming clams and oysters in order to get a better grasp on shellfish. Later, in the interview process, we also tasted the Slipper Limpets. Three interviews were then conducted with a local fish retailer and a chef. All interviewees had a background in the shellfish industry and were able to give us helpful information for this study.

Interviews were record (video and voice) in order to correctly capture respondents' reaction to the idea of consuming Slipper Limpets. Following the interviews, we

transcribed the text, made our own field notes and then reviewed these materials with the respondents to assure that attitudes and ideas were accurately captured.

After each interview we would spend about thirty minutes to an hour to analyze key ideas as well as comparing the text of the interview with other information gathered in previous interviews. The results and themes of our interviews are detailed below.

PRELIMINARY FINDINGS

Our retailer interview was with one of the managers at a local seafood market in Rhode Island. This interview was conducted to gain insight into the local shellfish industry and gain a better understanding for the Slipper Limpet and its consumption patterns in the area. Our second interview was with the chef/owner of a local restaurant who has won several food and wine awards. This interview provided insight into the restaurant industry and the types of concerns a chef might have when introducing a new food item to the menu. A second interview with the same chef was a hands-on experiment in which the chef tried to develop a dish using the Slipper Limpet.

Retailer Interview. From our discussion with the retailer, we learned that there is a small market for the Slipper Limpet that is primarily confined to the local Portuguese community. According to the retailer, however, "I don't think there's a big enough market for it right now." We also learned that there are no health concerns specific to Slipper Limpets – other than the standard issues that the retailer has to deal with for other shellfish. Finally, because of the lack of demand, the retailer did not have a ready source for Slipper Limpets, but could get them from the fishermen he dealt with when they were requested. The remainder of our conversation with the retailer focused on business concerns that, while interesting, were not relevant to the topic at hand.

First Chef Interview. As already noted, the chef who agreed to speak with us has garnered awards from *Esquire* and *Food & Wine Magazine*, as well as from local publications and organizations. When he lived in India, he was the chef at a Mumbai restaurant that was voted one of the world's best 60 restaurants by Conde Nast. Thus this chef fits the criterion of being a food opinion leader.

On our initial meeting, we discussed the restaurant business and the concerns the chef might have about introducing a new shellfish to his customers. He identified five issues that would need to be addressed before Slipper Limpets – or any new food product – would find their way to his menu.

The Name: Neither "Slipper Limpet" nor *Crepidula fornicada* was attractive. "I can tell you one thing is we would have to find a commercial name. I cannot imagine me putting Slipper Limpet on the menu."

Developing Tradition and the Adoption Process: "It's the individual chefs, what they make of it. If one chef makes it and it finds a good niche, and it really clicks and it falls into a trend then once you have one hit, other chefs will try it and then I think people kind of understand it and what the flavor of the dish is and then they might enjoy it for a while. … The only way I can see it being marketed is high end restaurants. Chefs might pick it

up and make it creative…. It's like any fashion industry: the designers design in an artistic way and then marketers fix it up."
Cost Issues: "If I can just use my local supplier and if comes through him, that might work. But if there are more people in between, how cost effective does it get? And if it's not, if I can't make a dish to make money on the dish, its never going to make it."
Safety and Reliability of Supply: "I have to see if it is safe to buy, I have to get it from a reliable source,"
Fit with the Restaurant's Image: "To me I don't cook for what other people want to see I cook for what I think is good, so I am in the middle of it, so nothing is too far out from my conception. … Probably I'd be able to do it in this restaurant, because people are used to seeing unusual ingredients and it goes with the image of the restaurant. My menu changes as much at 60-70 % every three months and then weekly specials, I just see a dish, and ingredient, a new ingredient, and I try to think and conceive it and then I enjoy the flavors then it goes on the specials, its like the normal process of creating any new product."

Second Chef Interview. After our initial discussion, the chef was interested enough in Slipper Limpets to bring them into the kitchen. We arrived at the restaurant with 10 pounds of Slipper Limpets. At first glance, the chef was overwhelmed and clearly puzzled. (As mention earlier, uncleaned natural Slipper Limpets have a hairy coating and are stacked one on top of another and therefore look nothing like the kinds of shellfish that chefs are accustomed to dealing with.)

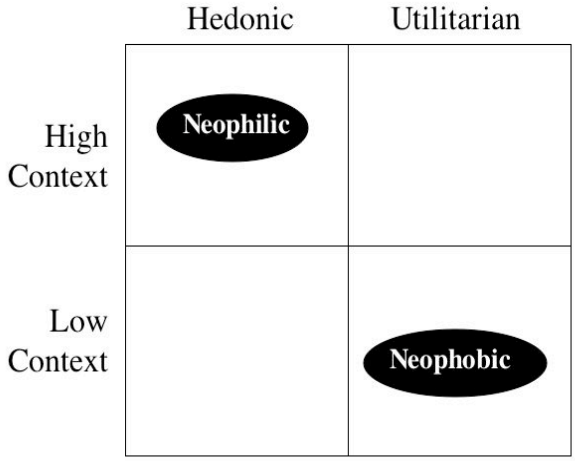
The chef began to pick them out of the bag and scrub the shell to see if it had an aesthetically pleasing appearance, such as the pearly inner shell of an oyster. From there he broke them apart (because there were stacked tightly on top of one another). He then grabbed a large sauté pan and went to work. He added butter, shallots, and white wine as well as the limpets. He steamed them for a few minutes, and then went in to taste. When he pulled out the first limpet from the pan he had a hard time getting the body out of the shell. Next, he had to decide whether to eat the tail or the muscle. He tried both and concluded that the tail was the better part. He immediately expressed his disgust, however, saying that he did not like the texture. His sou chefs tried it and said it mimicked the taste of a clam and that they liked it.

Even though the taste test was not an unqualified success, the chef determined that the shell was a perfect size and shape to hold the sauté sauce. Thus, the plating of Slipper Limpets held promise

REVISITING THE THEORY AND CONCLUSIONS

While reflecting on these interviews, we returned to the literature on the introduction of new and extreme foods to individuals and to societies. Combining the ideas from two studies allowed us to create the matrix illustrated below that helps classify consumers with regard to their likely adoption of *Crepidula fornicata*.

The structure of the matrix was proposed by Wansink, Sonka and Cheney [6], who suggested that consumers' approach to unfamiliar food can be classified by two cultural dimensions. A culture's overall approach to food is hedonic if people have "a greater sense of appreciation for the complexity of preparation and for the process of savoring food" (p. 354); it is utilitarian if food is consumed primarily for its energy and health value. The context dimension, borrowed from Hofstede [1], is either high or low, reflecting the relative strength of cultural attitudes and traditions on daily life.



Placement within the matrix was suggested by Veeck's [5] examination of individual (rather than cultural) food preferences. She proposed that approaches to new and unfamiliar foods may be dichotomous, with some people seeking novelty and variety (neophilic) while others being very distrustful (neophobic). Both individual and social forces are important in determining the approach an individual adopts. She also found that the meaning of one's encounter with a new food was conditioned by the context of the encounter: whether the tasting was viewed as an adventure, whether it took place while dining in a trusted restaurant, and whether there was social pressure to conform to the eating behaviors of others.

We thus were able to think about the implications for the introduction of Crepidula from within the resulting framework and consider which consumers would represent the most viable target markets and the marketing strategies that would work best with each target.

Both the high-context and low-context hedonic consumers would seem to be the best prospects. Both exhibit Veeck's neophilia, people willing to experiment and try new foods – foodies. In both instances, trusted chefs and restaurants will likely be important facilitators. The difference in marketing strategies would be that high-context hedonics will be more attracted to Slipper Limpets if the introduction emphasizes consistency with cultural practices, while an appeal to adventure and experimentation may resonate better with low-context hedonics. The value of these two groups is that they may function as opinion leaders for other consumers, thereby augmenting *Crepidula* marketing strategies.

Utilitarian consumers, on the other hand, may be more difficult to attract. High-context utilitarians, though, such as the local Portuguese community, may eat Slipper Limpets because of the close association between these shellfish and a cultural tradition of eating *lappas*. The simple availability of Slipper Limpets and the lack of availability of *lappas* might also facilitate the adoption of *Crepidula*. Low-context utilitarians, those for whom food is simply fuel, are not likely to be good prospects for *Crepidula* unless the shellfish become readily available in a variety of outlets and are well known for their health value.

Several changes, however, would need to be made before the Slipper Limpet would become commercially viable. Most importantly, the name needs to be more appealing. We propose that the "Slipper Limpets" be transformed into the consumer-friendly contraction "Slimpets." This word is short, easy to remember, and still related to the main origin of its name. Also, traditions must be established pertaining to how the Slimpet should be prepared, served, and eaten. High-context consumes will seek out this common ground so that they can recognize Slimpets as part of a culinary tradition.

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ERP SOURCING STRATEGIES: THE OUTSOURCING CASE AT A SMB

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ABSTRACT

Kanebridge is a small to medium sized business (SMB) that has successfully implemented an offshore application development relationship enabling them to achieve their project goals within the allotted scope, time, and cost. This paper discusses their lessons learned, from a practitioner's perspective but within the context of existing research. Discussed is the company's decision to rewrite their enterprise resource planning (ERP) information system, which led to a hybrid solution of in-sourcing and offshoring resulting in a successful conversion of thousands of lines of code and user interfaces of their legacy ERP system using a new IT software development environment.

Keywords: offshore, outsourcing, ERP, SMB, application development

SMB SOURCING STRATEGIES: A BRIEF LITERATURE REVIEW

Effective planning of IT resource use requires IT practitioners and business executives to recognize the IT competencies that enable their organization's to respond to environmental changes and exploit IT for gaining competitive advantage. Small and medium sized businesses are subject to many of the same IT decision-making considerations as large businesses to ensure their ongoing survival. This decision-making includes choosing the optimal software sourcing option when implementing new enterprise software systems.

Outsourcing is a commonly used business strategy and its use is predicted to grow by 65 percent annually to reach $147 billion in 2008 (McKinsey & Co, as cited in Marshall, 2003). According to Gartner, approximately 90% of all new businesses in the United States are small to medium sized businesses (SMBs) and the trend is toward their increasing use of outsourcing (Mears, 2006). Offshore outsourcing (offshoring) of software development is when a company procures programming or other development processes from a supplier providing manpower which is located in a foreign country. Skills that are most likely to be offshored are those that don't require close interaction between the client and offshore service supplier or sharing of a common knowledge base with the client's business users; such as programming (Bullen, Kaiser, & Goles, 2006). Some of the risks associated with outsourcing include loss of IT expertise, hidden costs, inappropriate contract, limitation of control and loss of privacy and security (Tafti, 2005). Given the lack of resources that small to medium sized businesses have relative to larger organizations,

offshoring can be a major undertaking for these firms and is not as prevalent as it is in larger firms (Carmel & Nicholson, 2005).

CASE STUDY

Kanebridge Corporation (www.kanebridge.com) is a leading wholesale distributor of standard-inch and metric industrial fasteners (nuts, bolts, screws, etc.). They are a privately-held corporation with approximately 70 employees headquartered in Oakland, NJ with distribution branches there and in California and Illinois. Their current annual sales exceed $13.5 million (the company requested to withhold specific financial data).

The company was incorporated in 1975 by principal owners Joe McGrath and Bobby Williams who saw a niche in the fastener market. McGrath and Williams saw that there was a demand for small package sizes with quantities less than a full keg which could be delivered in less time than it takes for the manufacturing process (6-8 weeks) to be completed. Over the years, the company's niche evolved from one in which they sold fasteners in relatively small package sizes to their current niche of carrying a wide range of fastener types available for same day shipping.

THE IT ENVIRONMENT AT KANEBRIDGE

Kanebridge has always been a leader in their industry in information technology usage. Soon after their inception in 1975, Kanebridge used IT to automate business processes, starting with an NCR billing machine, which automated inventory tracking using large magnetic striped cards containing data about customer sales and inventory levels. In the early 1980s, Kanebridge collaborated with Dymax Systems, a software development company, who developed a turnkey logistics system for the fastener distribution industry. This logistics system can be considered a precursor of Enterprise Resource Planning since it contained many of the back-office functionalities of ERP.

Kanebridge's business model for selling fasteners was starting to take off and they were still honing their business processes to implement their novel sales and distribution approach. Kanebridge knew that any competitive advantage they were realizing by computer automation of their business processes would quickly diminish as the Dymax turnkey logistics system for the fastener distribution industry became publicly available to any other company that wanted to buy it. Kanebridge could either continue using the Dymax logistics system as is, contract with Dymax to make enhancements to it as Kanebridge further evolved their business processes, or Kanebridge could hire their own full-time IT department for software development and support.

The IT Function at Kanebridge

Kanebridge decided to part ways with Dymax. As part of the agreement with Dymax, Kanebridge was provided with the source code for the logistics system and agreed they would not distribute it for profit or otherwise. To sustain their IT investment in the Dymax system, Kanebridge created two full-time positions for software development and data center operations. In 1983 Jim Kierstead, who was working at Kanebridge as an intern from a local college, was offered one of the full-time positions to design and develop software and maintain the computer

systems on a day-to-day basis. Over the years, Jim continued his education and training in information technology and his responsibilities expanded to include most of the major decision-making for IT technology usage and investment for the company.

Kanebridge's plan was to modify the existing applications when enhancements were necessary or would improve functionality. The system was sustained throughout the 1980s, but the system's limitations and extensive modifications were taking their toll on the functionality and performance of the system. At this point, a management decision was made to rewrite the logistics system software to enable branch transactions and to enhance it with additional integrating functionality. They decided that Cognos' Powerhouse 4GL was a suitable tool for them to use to develop their new ERP system. The new ERP system took several years to fully implement in a production environment and was completed in 1995. Currently, this legacy system now runs on a Hewlett Packard AlphaServer using an OpenVMS operating system. The system does not utilize a relational database to store and handle the data; rather it uses a flat RMS (Record Management System) file structure which is native to VMS.

Impetus for Change

The initial motivation behind Kanebridge having to contemplate the fate of its ERP system, yet again, came from the realization that their hardware platform and software environment would no longer be supported by the vendors who provided them. Hewlett-Packard announced that they were sun-setting sales and support of their AlphaServer. As a result of that news, Cognos announced they were maturing their PowerHouse 4GL product on the OpenVMS AlphaServer platform. Kanebridge had to consider their options. This combination of vendor announcements and resulting migration options was the impetus that motivated Kanebridge to reconsider their hardware, operating system, and software development environment.

DECIDING ON A COURSE OF ACTION

Kanebridge's IT history included 30 years of in-house proprietary software development environments. Was it time for them to consider replacing their custom ERP system with a purchased ERP package? A key factor weighing in on their consideration was that while many of Kanebridge's routine procedures are common to packaged software, there are many unique aspects to their business processes that provide them with a competitive advantage that would require customization to the code. For example, Kanebridge was unable to find any packaged software that could replicate their inventory forecasting logic. Taking into consideration their history of in-house development, their previous experience with customizing packaged software from Dymax, and their recent experience with vendor announcements, Kanebridge decided to implement a new IT strategy; whenever feasible, they would move away from their dependency on proprietary software development environments, away from a server-based development environment, and move toward a web-based development environment utilizing a client-server model.

In 2003 Kanebridge decided to start rewriting their applications using Java as the programming language. Java's open source and cross-platform capabilities contributed greatly to their decision. They decided to consider using outsourced help in the software development process,

mainly because they wanted to get the project done in a reasonable amount of time and the IT manager was the only Kanebridge employee who had software development skills. Kanebridge's history was to develop custom software in-house, but they were concerned that there was no Java software development environment comparable to the environment they had with Powerhouse. Having the Powerhouse software development environment had been a key factor in their previous successful software development project

The Decision to Outsource Development

Kanebridge president Joe McGrath met the president of SourceCode, Inc. at a meeting of small business owners. SourceCode Inc. is a software consulting company headquartered in Tarrytown, NY, not far from Kanebridge's headquarters. The two company president's became acquaintances and during one of their meetings they talked about Kanebridge's legacy system conversion project. SourceCode's president suggested that his company could provide Kanebridge with contract program developers to help them complete the project in a timely fashion.

SourceCode submitted a bid for the project based on lines of code, number of screens, and other calculations. The two companies could not agree on a fixed price fee structure, but they finally did agree on a time-and-material fee structure. A time-and-material fee structure is more risky than a fixed price fee structure. This type of agreement puts the responsibility to motivate the contract programmers on the client company, in this case Kanebridge. A fixed price fee structure puts the responsibility to motivate on the outsourcing vendor, since they have incentive to finish the project as soon as possible, rather than collecting billable hours as with a time-and-material based fee structure. The time-and-material fee structure worked well for Kanebridge because it motivated them to look for productivity tools to save time and money. This resulted in the development of a software tool to convert Powerhouse code into Java code.

Interestingly, Kanebridge and SourceCode did not use a formal contract. Rather, their agreement was based on a handshake. This was due in part to the pre-existing relationship between the two companies and the element of trust that already existed. The other reason there wasn't a formal contract, Kierstead suggests, was that there is an inherent motivation for both parties to keep their end of the agreement because SourceCode is getting their billable hours and Kanebridge was getting seasoned Java programmers who had ongoing experience working on the Kanebridge project; a win-win situation. One critical issue to Kanebridge, though, was that they had a legally binding agreement with SourceCode that the source code developed during the project engagement belongs to Kanebridge and each SourceCode developer involved with the project signed a non-disclosure agreement.

Offshoring

Kanebridge was ready to utilize additional outsourced Java developers. Two additional developers were added to the project to work at Kanebridge's NJ location, for a total of three on-shore consultants. SourceCode recommended that Kanebridge use their offshore services for additional developers. They decided to "start small" and added developers in pairs as needed until there was a total of six offshore developers working in India.

The SourceCode on-shore project leader handled all communication with the India project team. The offshore project team worked in two groups of 3 members each. Each group worked on a

different module of the system. The project team was able to gain productivity using a "follow-the-sun" strategy, leveraging the 9-1/2 hour time difference by sending programming specifications at the end of the on-shore work day and receiving the code back from India the next morning.

CONCLUSION AND LESSONS LEARNED

At this time, the conversion project is 90% complete. The monetary scope of the project was approximately $150,000 for the hardware and software and $1 million for the consulting services. Kanebridge has reduced the headcount working on the project so that only the three on-shore consultants remain. Their next steps are to disable the legacy system and after the company is solely using the new system, migrate the data files to a relational database management system. After that, they will update functionality and are considering including customer relationship management and data mining capabilities. On-shore and offshore sourcing will be utilized as necessary with a similar structure to what worked for them with this project – on-shore client-facing analysis, design, and testing and offshore structured coding.

This case demonstrated that networking events for small business owners can work to facilitate business relationships, as suggested by Davis, Renzulli, & Aldrich (2006). In Kanebridge's case, a networking event provided a connection to SourceCode Inc., their software service provider. One of the reasons why their outsourcing relationship worked so well is because the two companies are both similar in size. Kanebridge's Kierstead prefers to work with vendors similar in size because they often provide better customer service than the larger vendors, who may give preference to more lucrative contracts. And surprisingly, Kanebridge was able to have a successful agreement with SourceCode without the use of a formal contract. This is not a recommended best practice. Rather, this demonstrates that partnership and trust are critical to outsourcing success.

Make sure to develop a solid business case for *not* implementing a commercially available software package. If a package will solve your business problem, then it can be a much faster and cheaper solution than in-sourcing or outsourcing application development. In the case of Kanebridge, once they realized no existing ERP package would provide their unique custom functionality, which is a core competency, they stopped analyzing alternative solutions. They wanted the flexibility to be able to easily modify the code as their business processing needs evolve.

In a survey of SMBs that either outsource system development or provide software development services, Jennex and Adelakun (2003) found the following five critical success factors to be most important: 1) worker's skills, 2) client knowledge, 3) trust in the client-outsourcer relationship, 4) telecommunications capability, and 5) intellectual property protection. Comparing these critical success factors to Kanebridge's critical success factors, four out of the five were critical to them, too: It was critical that the outsourced IT staff were experienced Java programmers proficient with the software development products being used. SourceCode provided an on-shore contact point that was knowledgeable of Kanebridge's needs and the technology being used to successfully communicate project requirements with the offshore project team. Having the

project lead working out of Kanebridge's NJ office as the project contact ensured the availability of someone who understood the offshore culture and who acted as an interface to communicate requirements to the offshore developers and communicate issues to Kanebridge's IT manager.

A level of trust can reduce the transaction costs inherent in a relationship between two parties. If one side doesn't trust the other side, then resources that could be utilized elsewhere may be consumed to manage the risk that the other party won't keep their side of the agreement. The fact that there was a pre-existing relationship between the principles of the two companies and the existence of the intellectual property rights agreement created a trusting environment where Kanebridge felt comfortable that neither side would break their implied agreement.

The one critical success factor for SMB outsourcing that Kanebridge did not find critical was telecommunications capability. The nature of the programming work did not require large file transfers. The file sizes were relatively small so there was never any bottleneck due to transfer capability.

The most critical success factor for Kanebridge was cost. They found no advantage to offshoring other than the significant savings compared to on-shoring. Having no baseline to compare the productivity of off-shored resources, Kanebridge can only compare their output to the on-shore consultants'. The offshore productivity they achieved was approximately two-thirds that of their on-shore productivity. Still, the cost to have offshore developers is one-third the cost of on-shore developers, resulting in a savings of over half the cost to on-shore.

This case represents a successful endeavor by a medium-sized business to effectively manage their information technology resources to efficiently solve a business problem and in doing so, preserving an information system that provides them with a competitive advantage and establishing a new software development environment. In the process, they learned how outsourcing can be used as a tool to provide selected resources as needed. Kanebridge's outsourcing and offshoring experience should prove useful to other IT and business leaders as they look to leverage information technology to enable and drive their business strategies. The lessons learned described in this section provide insight for organizations to consider while implementing software development projects.

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USER ACCEPTANCE OF SAP IN THE PETROCHEMICAL INDUSTRY

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ABSTRACT

Enterprise Resource Planning (ERP) systems are widely used in most industries today because of the benefits they offer: improved integration of business processes, improved cost control, improved decision making, improved customer service, and improved profitability. Although much IS research has been published concerning acceptance of enterprise systems, adoption issues, or critical success factors in implementing an ERP system, little research has been presented that focuses on the user's intentions to use this technology. The purpose of this research is to attempt to extend the unified theory of acceptance and use of technology model proposed by Venkatesh and others in order to predict the acceptance of the SAP ERP system among its users in the petrochemical industry.

KEYWORDS: user acceptance, UTAUT model, SAP, petrochemical industry.

INTRODUCTION

Enterprise Resource Planning (ERP) systems and other corporate-wide systems, such as Supply Chain Management and Customer Relationship Management, are widely used in most industries today. These systems have become very popular because they integrate all of a company's business processes and share a common database (Topi, Lucas, and Babaian, 2005). Additional applications such as sales force automation, call centers, knowledge management, and data warehousing have emerged in recent years (Boudreau, 2002). As of 2005, U.S. firms have spent more than $165 billion on enterprise applications (Laudon, 2006).

Enterprise systems are increasingly used because of their potential to increase organizational and individual users' productivity, along with providing many other benefits (Hwang, 2005; Gefen, 2004; Ash and Burn, 2003, Mahowald and Levitt, 2005; Avalone, 1999). Because these enterprise systems are usually complex, they are both difficult and costly to implement successfully and numerous research studies indicate that the final benefits are often uncertain (Edwards, 2005). When businesses implement an ERP system, these complex systems usually create a burden on the employees to use them effectively (Topi, et.al., 2005).

User acceptance of information technology, specifically complex enterprise systems, has received much attention in MIS research journals during the past several years. Several models, such as the Technology Acceptance Model, Theory of Reasoned Action, and the Theory of Planned Behavior Cognitive, propose several constructs to explain end-users' acceptance behavior and IT usage (Davis, 1989; Ajzen and Fishbein, 1980; Ajzen, 1985).

Recently, the Technology Acceptance Model has been applied to ERP systems to explain the complex implementation and adoption issues by stakeholders and end users (Amoako-Gyampah & Salam, 2004; Gefen, 2004). Amoako-Gyampah & Salam (2004) found that the use of managerial interventions, such as training and communication, to influence the acceptance of ERP systems are supported, since perceived usefulness and ease of use contribute to intention to use ERP systems. Gefen (2004) also found that the perceived usefulness of ERP contributes to client assessment that their business relationship with the vendor is worthwhile.

The Unified Theory of Acceptance and Use of Technology (Venkatesh et al. 2003) is the most recent work in the area of explaining and predicting user acceptance and use of technology. This theory examined eight different models and integrated the components of those models into a single, unified model that is more predictive than any of the individual models alone. UTAUT considered and integrated the theory of reasoned action, the technology acceptance model, the motivational model, the theory of planned behavior, a model that combined the technology acceptance model and the theory of planned behavior (resulted in the decomposed theory of planned behavior), the model of PC utilization, the innovation diffusion theory, and the social cognitive theory.

Prior research in ERP has almost ignored the acceptance of SAP software from the perspective of individual users' intentions to use the technology. This paper attempts to address this gap in the research by incorporating SAP's acceptance in the framework of technology acceptance. From a pool of diverse attributes of a typical ERP software, we attempt to identify those attributes that are critical in facilitating the acceptance of SAP in the petrochemical industry. In doing so, we rely on the rich body of research on technology acceptance (Chau and HU, 2001; Taylor and Todd, 1995; Venkatesh et al., 2002).

The petrochemical industry in southeast Texas relies heavily on its investment in SAP software. Companies in this industry find, produce, refine, and market fuels and hydrocarbons. The main reasons these plants and refineries invested heavily in acquiring and implementing SAP was to become more efficient, more streamlined in carrying out their processes, and, of course, more profitable. Because these systems were designed to improve overall corporate productivity, performance, and the competitive position of the business, we feel that it is important for managers in the petrochemical industry to know which behavioral factors facilitate the acceptance of SAP by the users. Too much is at stake for management to ignore the factors that will increase and improve the use of the SAP system by the end users.

Although the direct influence of enterprise systems on a firm's productivity has been debated in the IS literature for several years (Stefanous, 2001; Ash and Burn, 2003), the importance of systems adoption by the end users is consistently emphasized for the successful implementation of enterprise systems (Joshi, 2005; Delone and McLean, 1992; Boonstra, 2003). Enterprise systems are usually large and complex systems involving different types of end users in the organization, which makes this understanding difficult and complex (Hwang, 2005).
Furthermore, when implementing an enterprise system in a global environment, which many of these plants in this industry are operating in, the complexity of adoption issues takes on even greater importance. Additionally, if these plants and refineries want to accomplish the goals of becoming more streamlined in carrying out their processes and more productive in their operations, they should want to avoid what other companies in many industries have experienced: ERP implementation project failure. This failure rate is currently estimated to be 85% (Hoffman, 1999).

Specifically, the purpose of this research is to examine the external factors which influence user acceptance of SAP in the petrochemical industry in Southeast Texas. The authors surveyed employees in this industry who used SAP as their enterprise system. From our review of the literature, we found that there were many streams of research dealing with user acceptance of ERP systems in general, but very few streams dealing specifically with SAP user acceptance, which was surprising since SAP is the market leader in ERP systems. At the beginning of 2005, SAP's U.S. market share was 44% for all business enterprise applications (Swartz and Auchard, 2005), with Oracle coming in second.

The current paper begins with a discussion of the theoretical background of the study and develops the conceptual framework. The following sections present, successively, the research model, research design, survey, results, implications, and the conclusion.

THEORETICAL BACKGROUND

Several models have been used in the research of user acceptance and usage behavior that provide explanation and justification for the variables under consideration. Each model will be examined briefly as to its relevance to the present study.

The TAM model, based on the theory of reasoned action by Fishbein and Ajzen (1975), was developed by Davis (1989) and expanded in Davis et al. (1989). According to Davis et al. (1989, p.985), the goal of the TAM model is "to provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified."

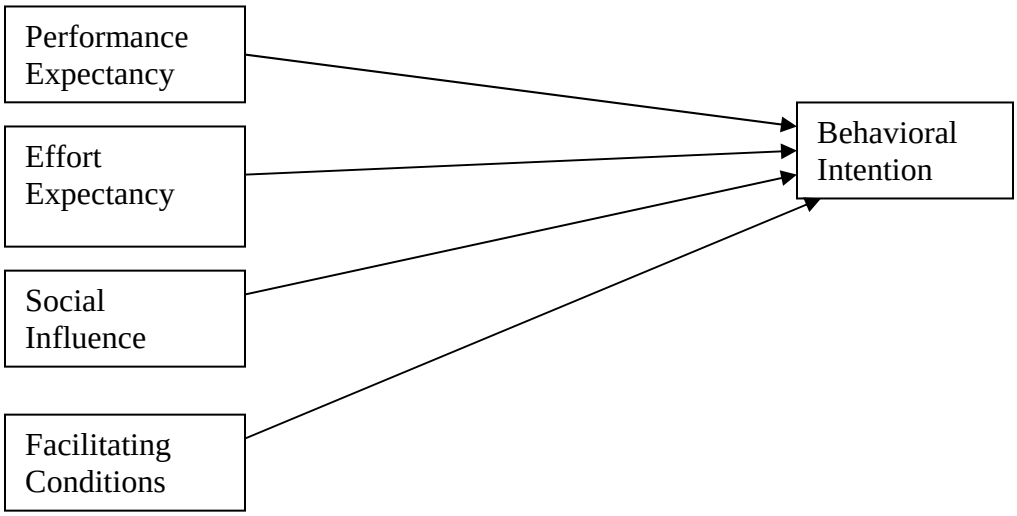
The TAM model does not include the variable of subjective norm that is used in the Theory of Reasoned Action (TRA). TRA is a mathematical formula that is used to predict behavioral intentions. It suggests that behavioral intentions are determined by a consumer's attitude toward some behavior or performance of some act as well as a subjective norm, which is based on the expectations of others concerning the consumer's performance of the act or behavior. The theory of planned behavior is based on Fishbein and Ajzen's theory of reasoned action (1975). The theory of planned behavior proposes that the perceived control the consumer has over the situation can also influence consumers' intentions.

The latest model to be developed from this body of research is a synthesis and unification of eight different models called the unified theory of acceptance and use of technology (UTAUT) by Venkatesh et al. (2003). This model examined the determinants of user acceptance and usage behavior—performance expectancy, effort expectancy, social influence, and facilitating conditions and found that all contribute to the usage behavior either directly (facilitating conditions) or through behavioral intentions (performance expectancy, effort expectancy, and social influence).

Although acceptances of various types of information technologies have been studied in the past, there is a paucity of research on the acceptance ERP systems in general and SAP in particular. The model is based primarily on UTAUT and is shown in figure 1. We propose that performance expectancy and effort expectancy will affect behavioral intentions, and the social influence and facilitating factors will provide additional explanatory power concerning user intentions to accept and use SAP.

RESEARCH MODEL

The research model is presented in Figure 1.



RESEARCH DESIGN

Operationalization of Constructs

The measures used to operationalize the constructs were taken from relevant prior studies. A thorough review of technology acceptance literature was conducted to identify studies in which constructs similar to the ones used in our study were operationalized. Adapting existing measures isomorphically to the context of the study, metrics for the study variables were generated. Table 1 summarizes the relevant prior research that served as the basis for construct operationalization.

TABLE 1

Relevant References for Research Model Constructs

Performance Expectancy (PE)	Davis (1989), Chau and Hu (2001), Venkatesh et al. (2003)
Effort Expectancy (EE)	Davis (1989), Chau and Hu (2001) Venkatesh et al. (2003)
Social Influence (SI)	Chau and Hu (2001), Venkatesh et al. (2003), Taylor and Todd (1995)
Behavioral Intention (BI)	Davis (1989), Chau and Hu (2001), Venkatesh et al. (2003)

SURVEY

We wanted to focus our research on the petrochemical industry of Southeast Texas because it is a major industry here. We did not know at the time which ERP system was being used, but we suspected most, if not all, of these plants were using some enterprise system. We contacted a representative from each plant or refinery via email and explained the purpose of our research. In many instances, the contact person was a former student who was happy to participate in the survey. We asked for the names and email addresses of ERP end users who would possibly want to participate in this survey. We asked for a broad representation of users, which would represent all departments or divisions that used the ERP system. Once approval was given by the corporate attorney at most of these plants, the names of the ERP users were sent to us, along with their email address. We received about 100 names from approximately 10 major plants or refineries.
Once we had the names and addresses, we emailed a cover letter explaining the purpose and nature of our project. In the cover letter, we included the link to our survey on the Web. We put our survey on the Web (surveymonkey.com) to facilitate receiving the responses and for conducting the data analysis. Approximately 73 people responded.

We conducted a pilot test with 73 returned responses. The pilot study revealed no problems or confusion about the survey instrument, confirming the suitability of the instrument. There are 28

parameters and there should be at least 280 cases for model testing. At this time, our sample size is insufficient for significant testing of model effects.

RESULTS

Path analysis measures suggest a poor fit of the measurement model. We suspect that the problem is with the small sample size. Adequate sample size is needed to assess the significance of a model. Kline (1998) recommends 10 times as many cases as parameters (or ideally 20 times). He states that 5 times or less is insufficient for significance testing of model effects. We are in the process of collecting more data.

IMPLICATIONS

The purpose of developing the research model in the paper is to explain the factors that may influence the acceptance of SAP by users in Petrochemical industry. This research has much potential. First, it fills a void in the ERP literature by addressing the factors that may facilitate the acceptance of ERP in Petrochemical industry. There are various types of ERP systems available (such as SAP, BEA, Horizon - MRP Plus, In-House Developed system, JD Edwards, NetERP, Oracle (PeopleSoft), TEKLYNX – SENTINEL, etc.) and knowing which factors (for example, ease of use or improvement in performance) contribute to its acceptance gives the Petrochemical industry the knowledge to choose a particular one over others. Second, the findings of this study will provide the Petrochemical industry a better understanding of user acceptance of SAP. SAP will enable managers to make better decisions by providing company-wide information. Third, from an academic standpoint, this study will enable us to test the modified UTAUT model in an entirely different context.

CONCLUSION

In this paper, we attempt to extend the unified theory of acceptance and use of technology (UTAUT) model proposed by Venkatesh et al. to predict the acceptance of SAP among its users in Petrochemical industry. We have relied on prior research in ERP and Technology Adoption. In addition to proposing a model for SAP acceptance, we identified the underlying dimensions that would measure each construct of the model (Table 2). We intend to test the model by conducting surveys among the users in Petrochemical industry. We are in the process of collecting data now. So far, we have a sample size of 73. While our model addresses a relatively less explored area of ERP research, we must acknowledge that the model that we propose in this paper is our initial endeavor and needs further improvements and refinements which is an agenda of future research.

References available upon request from Kakoli Bandyopadhyay

DIFFERENTIAL TECHNOLOGY USE: AN EXPLORATORY STUDY OF LOCAL GOVERNMENT WEBSITES

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ABSTRACT

E-government's primary goal is to utilize technology efficiently and effectively to provide online service to citizens. Relying on IS success model, usage literature and Resource Based View of the firm (RBV) the paper posits that local governments using similar technological resources (website) are creating websites that are not of equal sophistication. Sophistication was tested using the Government Website Sophistication (GWS) construct created for the study. Counties tested for GWS suggested that some were not providing the best service that they could. Demographic factors income, education and population size were positively related to GWS score.

KEYWORDS: website quality, IS Success, RBV, e-government initiative, Government Website Sophistication

INTRODUCTION

According to President George W. Bush's Management Agenda, e-Government is one of the key elements required to improve the management and services of the government[1]. The e-Government initiative has been defined as government's use of digital technologies to transform government operations in order to improve effectiveness, efficiency and service delivery to its citizens [27, 45, 48]. US has consistently lagged behind in instituting a digital government [68], and establishing e-participation with its citizens [61]. This could be attributed to government sectors finding it challenging to make the right IT investment decisions [9] and budget constraints [44]. Furthermore e-government funding itself is directed more towards security efforts than for general citizen needs [46]. Thus, given the financial constraints on IT spending faced by the various government agencies how can the e-government initiative at the grassroots level succeed?

Nicholas Carr [5], argued in his seminal work "IT Doesn't Matter?", that financial constraints are justified, since IT for a large part has become a commodity rather than a valuable resource. Thus, the key to getting added value from current IT resource lies in the ability to combine, coordinate, and exploit IT resources with other organizational factors that creates value [34]. All organizations having similar IT resources are unable to achieve such alignment [53, 69].

With this in mind, government institutions need to realize that success in achieving e-government initiative does not lie in the computerization of a government system. In the last few more people have used the internet for banking, making critical decisions and home improvement [19, 22, 33] than the mere 33% citizens who actually conducted business with

[1] http://www.whitehouse.gov/omb/egov/

government online [50]. Government websites if created with the citizens need in mind could result in numerous benefits, such as, cost savings [42], expanded citizen participation and increased government accountability. Whereas such a site can quickly become a liability if users have a bad experience after visiting it [49, 58, 65].

This study believes that the success of government websites lies in it being used. It posits based on IS success model that usage is based on the sophistication level of the sites published. Using PA local government county websites the following research questions are addressed: Are all websites equal when it comes to the level of sophistication in the websites that they publish? What are the salient components that a local government website should possess in order to best serve the population that it caters to? Lastly, is there a relationship between the demographic factors for the counties and their sophistication level?

THEORETICAL FOUNDATION AND LITERATURE REVIEW

Resource based view (RBV) approach

Using resource-based view (RBV) of the firm [67] the paper defines *valuable* resource as one that reduces cost, increase revenue or makes a process more effective and efficient [34, 47]. One such resource could be a website. Historically, RBT posited that a resource which *sustains* competitive advantage, and is worth developing has to be valuable, rare, imperfectly imitable and not substitutable [1]. But more recently Melville et al. [36], Barua et al. [2], and Wade and Hulland [62] have posited that it is becoming difficult for resource by itself to remain imperfectly imitable and provide sustained competitive advantage in the long run. Carr [5] in "IT Doesn't Matter" referred to this effect as *commoditization*. The proposition that IT is a commodity has been challenged by researchers and practitioners alike [2, 36, 53]. Researchers have reported that IT resource by itself may not always be of strategic value to the organization [11, 51, 64]. But the value lies in the ability to exploit IT resources with other organizational complimentary resources present [2 page 587, 15]. Investing large amounts of money to improve on an existing IT investment is not always the optimal solution [47].

IS success & technology usage model

The measure for IS success has not been clearly defined but has been established as a multi-dimensional concept that can be assessed at various levels [70]. Delone and McLean [14] proposed a model of IS success which suggest that the intention to use technology is dependent on external variables of system quality (measures of information processing), information quality (measure of information output) and service quality (measure of support). Furthermore, the benefit or success of a technology relies on the intention to use the technology. Therefore, a government website is considered a success if it used by the citizens. Getting citizens to use government websites achieves part of the e-government initiative [31]. Understanding factors that lead to the acceptance and use of technology have been addressed in the TAM - Technology Acceptance Model [12]. A meta-analysis of TAM literature identified two aspects of TAM that have received little attention (only 60%): the role of external variables and the role of different usage measures [28]. The authors argued that it is important to study external variables, because they are the ultimate drivers of usage. This study contributes to this effect by integrating the external variables of quality to explain factors that make a government website successful.

E-government literature review

Electronic-government refers "to the use by government agencies of information technologies that have the ability to transform relations with citizens, businesses, and other arms of government."[2] The *three* primary objectives of the e-Government initiative are to use information technology to make it easy for citizens to obtain services and interact with government; improve government efficiency and effectiveness; and improve government responsiveness to citizens [41]. E-government is being implemented at all levels of government. Local government was chosen as it is the grassroots of government and faces limited IT funding [44]. They need to utilize existing technology resources to get the maximum value out of them. E-government studies have charted the evolution and developmental stages of the government websites. Layne and Lee [27] are widely cited for the four developmental stages c*atalogue*, *transaction*, v*ertical integration and horizontal integration* which has been shown to follow similar evolution as commercial websites [45]. Citizens are likely to evaluate the e-government initiative based on the websites they visit.

Website assessment literature review

Usage of a website is contingent upon the quality of website [24, 38, 39]. Studies have investigated different categories of information, system, service and content quality [16]. For the purpose of this study website quality incorporates parts of all the quality measures. Website assessment specific to government websites have focused on the implementation of certain functionalities that facilitates the e-government objectives as discussed above; But not on web quality. Some may argue that web *quality* research is not needed on government website since government websites have been shown to have similar characteristics as those of commercial sites [45]. But government website differs in three ways; it caters to every citizen and not a specific group, one of its aims is to encourage visitors to get involved and interact in the running government and lastly citizens tend to visit government websites for utilitarian purpose rather than for hedonic purpose [8, 23]. A research gap therefore exits in establishing salient factors needed in a government website which will lead citizens to use it in order to obtain online services from the government. This study presents the Government Website Sophistication (GWS) construct to fill this gap in literature.

THE RESEARCH STUDY

The construct *Government Website Sophistication* (GWS) is defined as a comprehensive measure of government websites based on web quality as well as level of implementation of functionalities that support the e-government objectives. In the GWS construct a website is considered to be sophisticated when it is *used* by the citizens [13, 31, 37], *provide services* (what do you mean) that meet citizen's need [26, 55] and *contributes* to achieving the overall goals of the e-government initiative [27, 56, 60]. GWS was developed using a systematic method comprising of a five step process as suggested by Evans and King [17] and used by Gonzalez and Palacios [21] to evaluate corporate website. The process of evaluation begins with defining the *dimensions* which are broad areas to be investigated; establishing the *components* which are the specific elements used to measure the dimensions; r*ating* which is the score assigned to each dimension and component; *weights* which is the importance placed on each dimension and

[2] http//www.worldbank.org

component; and the final value which is the overall compilation based on both weights and ratings.

Dimensions

E-Democracy refers to "web-based public involvement" [54] or activities that increase citizen involvement online [59, 60]. Criteria for evaluating democratic process as suggested by Dahl [10] are effective participation, voting equality, enlightened understanding and control of policy agenda by the citizens. These criteria are made possible by having well informed empowered citizenry and transparency of government [4, 7, 26, 63].

E-Service in defined as the provision of service in cyberspace [52, 60]. For this study e-service sophistication is represented by the number of services the government is providing to its citizens rather than service quality defined by standard SERVQUAL measures such responsiveness, tangibles [43]. A highly sophisticated website should allow visitors to serve themselves (self service) and be able to meet the expectations of the visitors to the site [35, 52].

E-Security is defined as the provision of information in government websites that aids citizens and other government agencies during an emergency. A recent study by the National Association of Counties (NACo) and the National Center for the Study of Counties (NCSC) reported that three-fourths of local government have established an emergency management unit since September 11 attack [6]. Details on these units are posted on government websites.

E-Trust is defined here as the trust citizens have on e-government website's content and services being provided. This is different from trust in government itself [66]. Having trust in a website and the organization it represents is needed in order for citizens to rely on the content and information published in the site (Palmer, Bailey et al. 2000).

E-Usability refers to how well government websites are meeting the information seeking needs of the citizens[3]. It is commonly measured using three factors. *Effectiveness* which is the ability for citizens to successfully use the website to find what they need to accomplish the task they came for [3, 32]. *Efficiency* is the citizen's ability to quickly accomplish tasks with ease and without frustration. Lastly, *satisfaction* which is how much a citizen enjoyed the experience of using the site [30, 39, 57].

Components

Dimensions are measured based on the presence of components that best supports the theoretical foundation on which these dimensions were created. They include the presence of items such as email, discussion centers, and type of navigation systems (a full list could not be included due to space limitation).

Rating

If a visitors is not happy with a site the first time then there is very little chance that they will return to a website [18, 20, 40, 65, 71]. This study therefore restricted itself to the homepage to establish if components were present on the website. Other pages were only visited if linked from the homepage. The website components were coded objectively. A rating of one (1) was given if the component was present; a 0.5 if it was present but through a link on the homepage and a zero if it was not present in either of these cases. A code book was created to keep the analysis as accurate as possible.

Weights

For this pilot study weights were considered to be uniform across the five dimensions.

[3] http://www.usability.gov/basics/whatusa.html

METHODOLOGY

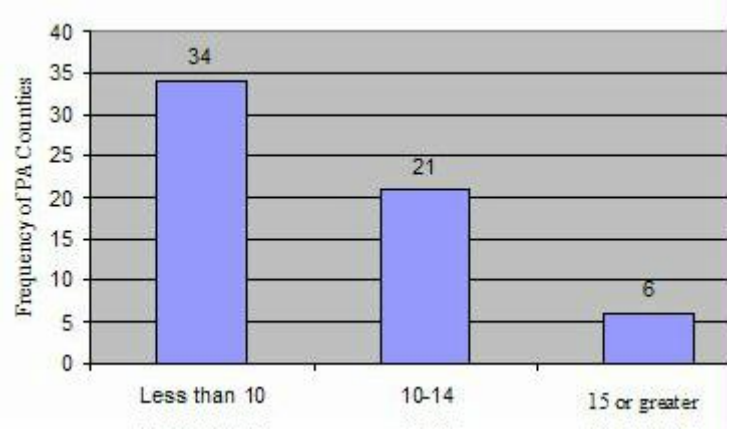
GWS

Each component was code with a one, 0.5 or zero based on its presence on the homepage. Sum of all components provided the e-dimension score. Sum of the dimensions with equal weights resulted in the final GWS value.

Sample

The State of Pennsylvania (PA) with its 67 counties was used for this study. Out of 67 counties three counties had an URL but the sites were not operational and three did not have a website. A separate sample used to partially validate study came from the top rated national counties as awarded by Center for Digital Government. Data from the US Census Bureau for PA counties were captured to from the bureau's site for analysis purposes.

RESULTS & DISCUSSION



The findings provided major insights to the sophistication level of PA counties. First, there is a vast difference in sophistication level within PA counties. This implied that not all local government websites are providing the same level of service even though they all have the capacity to do so. Second, PA counties are far behind some of their national counterparts in achieving the e-government initiative using government websites as one of the resources. Only two out of the 61 operational PA county websites were moderately sophisticated. Montgomery and Chester obtained a score of 17 out 36. They both had a population higher than 200K and household income over 100k. The study found that income, population and education were positively related to GWS score. The least sophisticated government websites in PA were those of Washington, Juniata and Mclean counties. Population size and income level of these counties were much lower than the top level counties.

Among the five dimensions e-democracy was the strongest in PA with 37%. This is an encouraging finding since e-government initiative's goal is to find ways to improve the democratic process digitally. E-service came in third with 27%. E-Usability and E-Trust dimension had a very low rating (21% & 20%). These dimensions can be thought of as "hygiene factors" [72] which when not present makes the website less functional and serviceable and can cause dissatisfaction. The component that has been incorporated the most by PA counties (56%) is the "dedicated domain name." PA counties also rated high in allowing citizens the opportunity to reach their government officials by having their contact information available.

Lastly, the study found that income, population and education were positively related to the GWS. There could be many reasons for this relation to exist but none that was extensively tested in this study due to data constraints. It can be argued that a county with higher income and more educated citizens is likely to have a household that has access to both computers and the Internet [25, 29] and are likely to be more technologically savvy. To meet the needs of these citizens, local governments are creating better websites and have higher GWS. County with larger population are likely to be searching for ways in which they can provide service in an economical manner. They may tend to transition some of the services online so as to effectively reach more citizens. In addition, a larger population maybe better at letting their local government officials know of their needs which are then reflected on the sites.

CONCLUSION

The study found that PA counties could do more with the websites they have. The GWS was low relative to other national websites analyzed. The steps needed to increase their GWS would not require any additional investment in technology. Most of them can be achieved by measures such as improving the quality of design and layout. Since e-usability was one of the main weaknesses of PA counties there is a need for these local governments to use some of the existing resources to improve this dimension.

This study posited that institutions do not always use their existing technology to get the maximum value possible from them. Using the GWS construct the study was able to empirically show that a website created by similar institutions with similar technology resource failed to derive similar output.

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A SYSTEM FOR MANAGING RISKS ASSOCIATED WITH EMPLOYEES INTERACTIONS WITH THE IT INFRASTRUCTURE

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ABSTRACT

This paper presents a proposal for a system by which a given organization would manage human related security breaches as they arise within the IT environment specific to that given entity.

KEYWORDS

Social engineering, balanced score card, fuzzy system

INTRODUCTION

These days, the risks associated with activities of an employee affecting critical areas of an IT infrastructure are too high to ignore. These activities are associated with access to sensitive information and the IT means to access them. The processes that the system will handle in this new type of risk management are similar to those a security expert would handle. We are not talking about computer forensics, but forecasting future breaches through real time and continuous monitoring of all subsets of the IT infrastructure that is directly used by some or all employees. One of the many risks an organization needs to be aware of is what we will label as 'internal social engineering' [7]. The proposal is related to previous work we have done in this area [9]. In the context of information security and human factors in guarding against attack against a corporate IT infrastructure, social engineering is the process by which a person receives confidential information to gain access to restricted areas by acting or posing as someone else. The social engineer uses deception to reach his/her goal [7]. No matter how secure a corporate IT infrastructure is, it is still vulnerable to attacks through means that would overcome even the strongest firewalls and encryption systems [2]. The safest system still has the human nature as one of the weakest links in its chain of defense. It is well known in the computer security business that securing an IT domain should take into consideration the implementation of well defined protocols [1]. Among these protocols are rules by which employees of a corporation will interact with each other and with persons other than their colleagues. In many cases, a disgruntled or even careless employee can cause more damage as

his/her actions may go unnoticed for a long time. There is too much managerial focus on external breaches in security caused by non employees, while many systems' managers ignore the security threat posed by in-house. The chain in the business of IT security has a more complex structure than what is depicted in most text books. Furthermore, there is evidence that the most volatile and unpredictable links in this chain are actually human and not an encryption program nor an expensive firewall. The human factor is ignored most of the time because of the level of trust in the screening of potential employees during the hiring process and respect for employees' privacy.

It is time for organization relying on IT for day to day business to start focusing on internal risks associated with their own employees [10]. A new risk management approach in this area must be created. A new system by which a knowledge base is created and populated with historic facts either from external sources or simulated internally. Virtual and transparent 'E-drills' in the area of IT security must be conducted to detect risks within the organizations before they arise in reality [5][6].

Further more, any entity should be treated as a heterogeneous dynamical system where human interact with other humans and processes interact and react to other processes.

PROPOSED SYSTEM

An initial phase of this project consists of collecting cases that are pertinent to developing such system. Most documented cases are related to past experience of computer forensics dealing with system intrusions and network attacks. A small set of cases deal with acts of deception and social engineering. Some literatures do focus on this side of the problem and the remedies offered are adoption of new protocols and policies dealing with employees' behavior interacting within an IT infrastructure [1][3][4]. Part of this phase is about discussing the research and hopefully getting good feedback on what constitute good practices in policing employees' interaction with the local environment and remote systems. We decided to restructure any knowledge equivalent to past experience that necessitated computer forensics. In this case, while computer forensic trace a set of event back to try to find the source of a problem, we need to re-arrange those events to playback different scenarios in relation to there respective environments in order to pinpoint all potential entities involved or may have being involved. Computer forensics is using what was left after an attack to trace a chain of events to the culprit [12]. We are focusing on other hidden variables that can only be inferred with deeper analysis of what could/might have happen. We intend to project some paranoia into the process to exaggerate known consequences to come out with the worst case scenario for each case studied. At this stage, our feeling is that the task is time consuming and difficult at the same time but doable. The analysis process is done without the help of any tool in order to maximize human expertise and extract the necessary and efficient approaches that we can implement later in our proposed system.

The next stage in developing the system is to design an Agent based subsystem that help in collecting information, and mining the knowledge base for patterns that map to a known profile(s) of security breaches. An example of such approach, although in a different context than security, is depicted in [8]. We plan to complement the system by exploring the use of balanced score card by all employees, implementing day-to-day survey to collect information associated with events related to employees interaction with each other, and finally, the use of fuzzy logic. A fuzzy logic subsystem expands the whole system to one that inter-relates experts

and non-expert observations and findings within the organization, and help in generating decisions that best safeguard the organization against human triggered security breaches.

CONCLUSION

While there are many applications out there used to directly monitor the employee's interaction with the IT infrastructure, this paper outlined a proposal for a system that goes one level deeper to mine for patterns of security breaches as they arise and by detecting dependent and remote events. The system, unlike traditional monitoring system, can utilize partial information and correlate it with other newly detected or stored pattern to decide if an ongoing security breach is developing. The proposed system together with the proactive approach of involving employees through the adoption of a balanced score card in the area of security is a novel approach.

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CLASSIFICATION OF STATISTICAL DATABASE SYSTEM (SDB) SECURITY MEASURES

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ABSTRACT

This paper outlines statistical database system (SDB) security from a viewpoint of the protection against the threat of statistical inference. The SDB security techniques discussed are classified into non-perturbative, perturbative, camouflaging, and hybrid approaches based on protection requirements. This paper represents a first step in the development of a comprehensive classification system based on the key characteristics of each SDB security measure. This research intends to increase the understanding of SDB security methods and the associated trade-off between data utility and data confidentiality.

INTRODUCTION

Information security in statistical database systems (SDB) refers to the SDB's ability to reliably and securely handle sensitive information and protect against the threat of an attacker who is attempting to gain access to sensitive information such as health information or salary or an organizations' private information such as financial information [3]. The SDB security requirement leads to a problem of the "conflict between the individual's right to privacy and the society's need to know and process information" [24]. Accessibility to today's networked SDBs increases the system's value to the users but also increases SDB vulnerability.

However, accessibility is not the only factor that increases an SDB's vulnerability. Other factors, such as the typical practice of simultaneously storing sensitive and non-sensitive relational data together in the database, also increase SDB vulnerability. Additionally, there is often the need to provide information on sensitive data in aggregate formats. Both of these factors increase the SDBs vulnerability to statistical inference where the data revealed as aggregate information is combined with other pieces of information to deduce individual confidential data on the records in the database [8].

SDB Concepts

A SDB is a special kind of database (DB). SDBs are designed to answer statistical queries such as count, mean, standard deviation, minimum and maximum, and correlation queries [6]. Most SDBs are designed as relational DBs consisting of two dimensional tables storing information about real life entities and are composed of records (the rows of the table) and attributes (the columns). Each record, or instance, contains one group of related data including the attributes. Each field represents an elementary unit of data. A typical relational DB model consists of multiple tables. The DB schema contains information about the logical structure of database, more specifically how the DB tables are related.

Types of SDBs

SDBs take on many different configurations based on their intended use and application [29] [30]. Some important factors influencing SDB design include (1) stand alone version or networked, (2) data

changes over time or does not change at all, (3) the system handle queries as they arrive or in some other manner. These factors help to classify SDBs based on their use. SDBs have been classified by the following system environments; Online-Offline, Static-Dynamic, Centralized-Decentralized, and Dedicated-Shared [30]. System environment may greatly impact the complexity of the SDB data protection problem as do performance requirements.

Inferential Disclosure in SDBs

Inferential disclosure refers to the ability of an attacker to infer either the identity of an entity to which a particular record belongs (re-identification) or the value of a confidential variable (predictive disclosure) [31]. Disclosure can be complete or partial. Complete disclosure, also called exact disclosure, is said to occur if the exact value of a sensitive datum is revealed. Partial disclosure may also be referred to as "statistical disclosure". Statistical disclosure is said to occur if information from a sequence of queries makes it possible to obtain a better estimate for a sensitive data point than would have been possible from only a single query [2]. Disclosure control in SDBs has also be referred to as a systems ability to provide answers, usually as point estimates, to user's queries while necessitating a large number of independent samples to obtain a small variance of the estimator [7].

The adequacy of disclosure control mechanisms and the level of disclosure control that is acceptable are dependent on the capability to prevent exact disclosure while providing statistical disclosure control [1]. If there is a common theme in these various views on disclosure control, it is that any disclosure control technique must consider both exact disclosure and partial disclosure. While the level of partial disclosure is imperative when discussing the adequacy of a disclosure control mechanism, it is not the only factor to consider. The next most obvious factor to consider is the level of "information loss" which is essentially traded for the disclosure control [1]. There are also several other additional factors to be considered including the system robustness, ability to protect data (numerical and categorical), ability to protect more than one attribute, suitability for the protection dynamic SDBs, richness of information given in answers to queries, cost of implementation, and overall usability [1].

CLASSIFYING SDB SECURITY TECHNIQUES BASED ON REQUIREMENTS

Approaches to protecting SDBs against statistical inference can be divided into four primary categories based on protection requirements: (1) non-perturbative, (2) perturbative, (3) camouflaging, and (4) hybrid techniques. The first determination to be made regarding protection requirements is the type of data to be protected. If the data is numerical, not categorical or binary, and exact answers are required then non-perturbative approaches are appropriate. Examples of non-perturbative techniques include conceptual, recoding and query restriction techniques that allow for unbiased exact answers to be given. However, these techniques may severely restrict query responses in order to protect sensitive data [31]. If exact answers are not required then perturbative approaches may suffice. Data-masking techniques exemplify the perturbative approach and provide protection by altering the data used for query responses or by altering the query responses directly. If deterministically correct answers are required and interval answers satisfy user requirements then camouflaging approaches are adequate. Camouflaging approaches rely on interval protection to provide deterministically correct query answers in the form of intervals. Finally, hybrid methods combine techniques from two or more approaches providing a blended approach and often increasing effectiveness. Figure 1 below graphically illustrates the classification scheme based on protection requirements. The specific protection classes are illustrated through examples of specific techniques within each class in the following paragraphs.

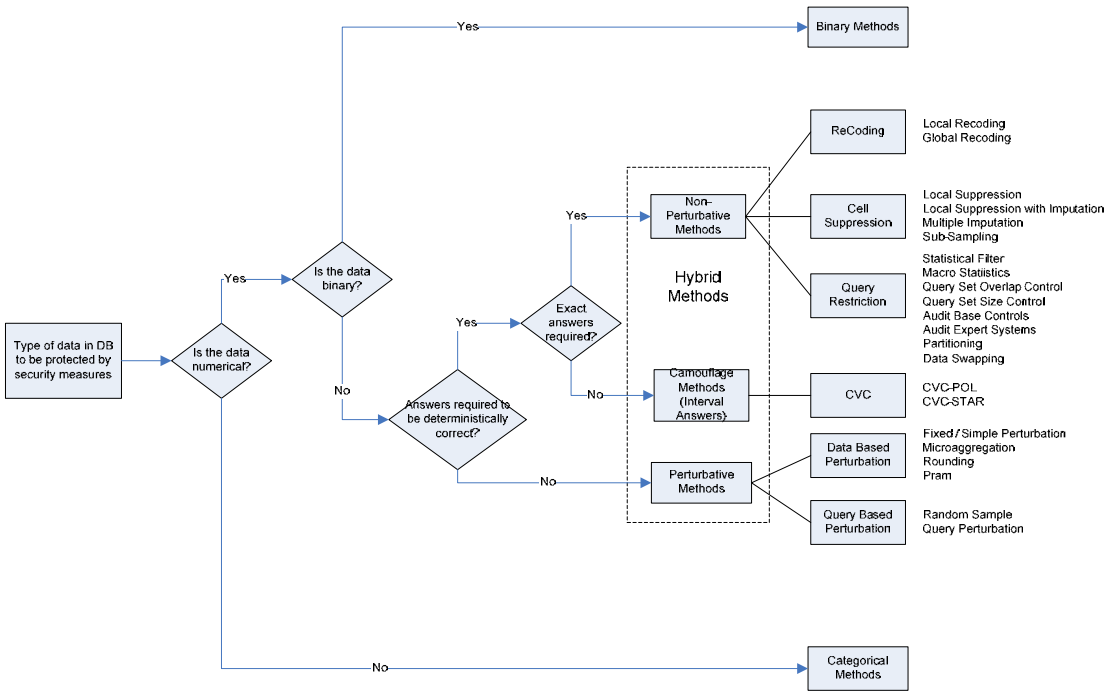

Figure 1: Classification of SDB Security based on Protection Requirements

Non-Perturbative Approaches

Query restriction is a non-perturbative approach that protects sensitive data by enforcing rules that restrict query answers in an attempt to avoid the release of information that could potentially lead to the disclosure of sensitive data. Query restriction is discussed in [4], [10], [11], [16], [18], and [26]. One very simple technique is based on query size, where queries of very small size or very large size simply are not answered. Friedman and Hoffman [12] point out that simple query restriction alone may not guarantee confidentiality. They proposed an expanded query-set size control mechanism that takes into account the logical relationship between separate queries and determine an "implied query set." However, it is easy to show that the number of implied query sets grows exponentially with the number of attributes and therefore calculating and storing the implied query sets could be exorbitantly expensive in terms of computation and storage. Furthermore, it has been shown that sensitive statistics can still be inferred from the allowed query answers [9].

Query-set overlap techniques were developed to overcome this problem [28]. However, these techniques are burdensome because they require extensive auditing and comparing incoming queries with all the query answers previously released. Other approaches to this type of query restriction include using an audit expert system [5] and the combination of query restriction and conceptual design techniques that take into account the number of attributes such as logical partitioning and cell suppression. Conceptual techniques for data protection are introduced in the conceptual design phase of the database. Two familiar types of conceptual techniques are the lattice model and conceptual partitioning [5].

Perturbative Approaches

One example of the perturbative approach is data masking which refers to the changing of the sensitive numerical data systematically so that a user querying the data cannot determine the sensitive data with certainty. Data masking techniques are introduced and discussed in [2], [8], [19], [20], [21], [22], [25]

and [27]. In some realizations of data masking, the changing of sensitive data is accomplished by replacing data with data from the same confidential field, or swapping the data. This technique is appropriately called data swapping or data shuffling [23]. However, when the replacement data does not come from the confidential field, but is randomly generated, the name perturbation is often used. There are a number of ways that the sensitive data may be perturbed. For instance, one technique is to view the sensitive numerical data in a SDB as a sample belonging to a distribution of a population. Then by either replacing the "exact" sample with another sample from the same distribution or by simply using the distribution, rather than the exact data, to answer queries disclosure of "exact" information can be avoided. Data masking may allow for unlimited query answers.

Camouflaging Approaches

Camouflaging techniques “hide” the confidential data within a larger data set and answer queries with respect to that set. The Confidentiality via Camouflage (CVC) approach is a camouflaging technique where query responses given are deterministically correct and in the form of intervals. Deterministically correct refers to the property that the answer intervals are guaranteed to contain the exact answer [17]. The CVC approach is somewhat unique in that it incorporates the advantages of both perturbation and query restriction while eliminating some of the major disadvantages [17]. The user is also given a deterministic guarantee as to the maximum deviation from the exact correct answer. However, while answers are deterministically correct CVC has the down side that query answers are not point answers. Advances in and the application of the CVC approach are discussed in [14] and [15].

Hybrid Approaches

The application of hybrid approaches, the combination of techniques from two or more of the aforementioned security classes, have been developed to provide a better balance between answer utility and the preservation of data confidentiality. One such approach combines random data perturbation and query restriction, a non-perturbative technique, providing protection that allows for the answering of all queries posed. Data is protected while maintaining consistency of exact answers for queries that are safe to answer and protected answers for others [13]. This approach allows for the answering of a subset of queries that can be safely answered exactly and the answering the remaining subset of queries using randomly perturbed data to deliver a high level of utility while delivering the required protection [13].

FUTURE RESEARCH

Several concepts of SDB security have been discussed in this paper and a preliminary classification scheme of approaches to SDB security based on the data protection requirements was presented. Future research will aim to further break down SDB security approaches based on additional protection requirements such as the specific threats presented in various SDB security environments.

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A NEW SIGMOID FUNCTION-BASEDCONSENSUS RANKING METHOD

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ABSTRACT

The problem of aggregating individual rankings to create an overall consensus ranking representative of the group is of longstanding interest in group decision making. The problem arises in situations where a group of *k* decision makers (DMs) are asked to rank order *n* alternatives. The question is how to combine the DMs' rankings into one consensus ranking. Several different approaches have been suggested to aggregate DM responses into a compromise or consensus ranking, however, none is generally recognized as being the best and the similarity of consensus rankings generated by these algorithms is largely unknown. In this paper, we propose a new weighted-sum ordinal consensus ranking method (WCM) with the weights derived from a Sigmoid function. We run Monte Carlo simulation across a range of *k* and *n* to compare the similarity of the consensus rankings generated by our method with the best-known method of Borda-Kendall [14] and two other commonly used techniques proposed by Beck and Lin [3] and Cook and Kress [5]. WCM and Borda-Kendall yielded the most similar consensus rankings (mean *tau-x* = .91). As the number of alternatives to be ranked increased, the similarity of rankings generated by the four algorithms decreased. Although consensus rankings generated by different algorithms were similar, differences in rankings among the algorithms were of sufficient magnitude that they often cannot be viewed as interchangeable from a practical perspective.

INTRODUCTION

The problem of aggregating individual rankings to create an overall consensus ranking representative of the group is of longstanding interest in many interdisciplinary fields like organizational sciences, psychology, public policy administration, marketing research, and management science. In particular, the problem of consensus ranking when the individual preferences are represented as ordinal ranking vectors has been investigated extensively by many researchers. Numerous integer programming, goal programming, and multiple criteria approaches have been proposed to aggregate DM responses into a compromise or consensus ranking since the early work of Borda [4], Arrow [2], and Kemeny and Snell [13]. However, none is generally recognized as being the best and the similarity of consensus rankings generated by these algorithms is largely unknown.

The simplest form of group consensus, the majority rule, is used when individual preferences are presented as ordinal ranking vectors. Borda [4] proposed the "Method of Marks" to derive a

consensus of opinions by determining the average of the ranks assigned by DMs to each alternative, with the winning alternative being the one with the lowest average. The Borda-Kendal (BAK) technique is the most widely used consensus ranking method in practice because of its computational simplicity [12]. Another popular method for deriving a group consensus is to define a distance function for all rankings and then finding the ordinal ranking with the minimum distance. Kemeny and Snell [13] proposed a distance measure that represented the degree of correlation between a pair of rankings along with a set of axioms similar to those given by Arrow [2] and showed that the median and mean rankings are acceptable forms of consensus. Cook and Kress [5] extended Kemeny and Snell [13] theory by suggesting a method for representing strength of preference within an ordinal scale.

Ali et al. [1] presented an integer programming approach for consensus ranking. Iz and Jelassi [11] proposed goal programming for formulating and solving consensus ranking problems. Cook and Kress [6] proposed an ordinal ranking model for on the basis of multiple criteria.

In this paper, we propose a new weighted-sum ordinal consensus ranking method referred as weighted-sum consensus model (WCM) with the weights derived from a Sigmoid function. We first identify an initial preference matrix, R, where the *i-th* row corresponds to the *i-th* DM and the *j-th* column corresponds to the *j-th* ranking. The element in the *i-th* row and the *j-th* column, r_{ij}, shows the number of times alternative i is ranked 1^{st}, 2^{nd},…, and n^{th}. Next, ranking of r's are weighted according to a Sigmoid function. The Sigmoid function produces an "S-shaped" curve with larger weights for extreme cases (top and bottom alternatives) and smaller weights for the center (middle alternatives). A detailed discussion of sigmoid function properties can be found in Grossberg [9]. When discussing the process of rank ordering candidates (employees or applicants), Guion [10] notes that extreme judgments (e.g., distinguishing the best from the worst employees) are easy, but differences near the center of the distribution are harder to identify (p.545). This observation is consistent with an analysis of rankings from Olympic figure skating competitions where Truchon [17] found that most cycles (i.e., intransitivities) involved middle ranked skaters. Both of these observations are consistent with the longstanding finding from perception and psychophysics research that judgment time is inversely related to the distance between the stimuli being judged [7]. The Sigmoid function used in our weighted sum model ensures exponentially differentiable weights among the top, bottom, and middle rankings by providing heavier weights to the extreme judgments where the best and the worst candidates are more distinguishable than the middle candidates. We also examine the similarity in rankings generated by our method with the best-known method of BAK and two other commonly used techniques proposed by Beck and Lin [3] and Cook and Kress [5]. We use Monte Carlo simulation to examine the extent to which these algorithms yield similar rank ordering across a range of k and n.

Beck and Lin [3] have developed a procedure, known as maximize agreement heuristic (MAH), for approximating the optimal consensus rankings. MAH is intended to derive consensus orderings that reflect collective DM agreement. An agreement is defined as a case where alternative i is preferred to alternative j by a given DM and alternative i is ranked above alternative j in the final consensus ranking. A disagreement is a case where alternative i is preferred to alternative j by a DM and alternative j is ranked above alternative i in the final consensus ranking. Under the MAH, alternative i is positioned above alternative j in the final

ordering if the difference in total DM agreement and disagreement about the relative orderings of alternatives *i* and *j* is positive, and alternative *j* is positioned above alternative *i* if this difference is negative. These positioning assignments are iteratively made based on the maximum absolute agreement/disagreement difference of all unassigned alternatives.

Cook and Kress [5] have suggested a more complicated method referred to as the consensus ranking model (CRM) for representing strength of preference within an ordinal scale. In CRM, a DM orders *n* alternatives in *q* positions where $n \le q$. The resulting ranking shows the DM's order of preference and the relative positioning of the alternatives represents his or her intensity of preference. CRM guarantees common units across DMs if each DM orders the same number of alternatives into the same number of positions. In order to minimize the number of iterations in our Monte Carlo simulation, ties are not considered in CRM ($n = q$).

The remainder of the paper is organized as follows. The next section describes the mathematical details of our model followed by a description of our study in Section 3. In Section 4, we discuss our results and in Section 5, we present our conclusions.

THE WEIGHTED-SUM MODEL

To formulate an algebraic model of WCM, let us consider a general consensus ranking problem with k DMs and n alternatives. Let us assume r_{ij} is the alternative number of the *i-th* DM on *j-th* ranking ($i=1,..., k$ and $j=1,..., n$) and $R = (r_{ij})$ represents the matrix where the *i-th* row corresponds to the *i-th* DM, the *j-th* column corresponds to the *j-th* ranking, and the element in the *i-th* row and the *j-th* column, r_{ij}, is the alternative that the *i-th* DM put into the *j-th* ranking.

Let us further assume f_{mj} is the number of times alternative *m* appears in column *j* of matrix *R* ($m=1, ..., n$ and $j=1,..., n$) and $F = (f_{mj})$ represent the matrix where the *m-th* row corresponds to the *m-th* alternative, the *j-th* column corresponds to the *j-th* ranking, and the element in the *m-th* row and the *j-th* column, f_{mj}, is the number of times that alternative *m* is placed in the *j-th* ranking. We maximize w_i, the total weighted-sum score for alternative *i* $\left(\underset{i=1,...,k}{Max.} w_i = \sum_{\substack{j=1 \\ i=1,...,k}}^{n} f_{mj} . S_j \right)$; where S_j is the weight of the *j-th* ranking using the Sigmoid function $\left(S_j = \frac{1}{1+e^{-x}} \right)$; x is the linear interpolation bounded by $\pm\alpha$; and α is the linear limiting control used to ensure exponentially differentiable weights among the top, bottom, and middle rankings.

THE STUDY

In this study, we used Monte Carlo simulation to compare the performance of our method (WCM) with BAK [14], MAH [3], and CRM [5]. Our testing platform was a Pentium 4 CPU, 3.33 GHz, with 1.00 GB RAM, running under Microsoft Windows XP.

We randomly generated rankings of *n* alternatives for each of the *k* DMs. Initial individual rankings for each trial were generated using uniformly distributed random numbers from the Mersenne Twister [15] random number generator. Each of the four consensus algorithms was then used to aggregate the individual rankings into a single consensus ranking of all *n* items for all *k* DMs.

For each scenario, the number of alternatives to be ranked, *n*, varied from 3 to 6. The number of DMs, *k*, varied from 3 to 7. One thousand repetitions for each *n,k* combination were conducted. The result of the experiment was twenty separate unique *n,k* combinations. One thousand repetitions of each unique *n,k* combination resulted in 20,000 total trials. For each trial, each of the four techniques was used to generate group consensus rankings. Therefore, the analysis generated a total of 80,000 data vectors in the form of group consensus rankings.

THE RESULTS

For each trial, where each trial begins with the same initial individual DM rankings of the *n* alternatives, there were four consensus rankings of the alternatives (WCM, BAK, MAH, and CRM). One goal of our Monte Carlo simulation was to examine the extent to which the four algorithms yield similar rank ordering across a range of problems with *k* DMs and *n* alternatives.

For each combination of *k* and *n*, Table 1 reports the mean and standard deviation of the *tau-x* [8] coefficients comparing each of the four consensus algorithms to the other three algorithms. We conducted several analyses to help clarify the results presented in Table 1. First, it is noteworthy that across all 120 cells in Table 1, the mean similarity (*tau-x*) of rankings was .82 (SD = .18). This indicates that the consensus rankings generated by the four algorithms (WCM, CRM, MAH, and BAK) were somewhat similar.

		CRM				MAH				WCM			
		3n	**4n**	**5n**	**6n**	**3n**	**4n**	**5n**	**6n**	**3n**	**4n**	**5n**	**6n**
BAK	**3k**	.94	.82	.76	.73	.94	.90	.88	.87	1.00	.92	.93	.89
	4k	.75	.73	.69	.70	.90	.86	.85	.83	1.00	.90	.91	.86
	5k	.84	.77	.73	.73	.92	.87	.84	.84	1.00	.88	.90	.85
	6k	.76	.73	.73	.72	.89	.86	.84	.83	1.00	.86	.88	.83
	7k	.81	.75	.73	.72	.88	.86	.83	.82	1.00	.85	.89	.84
CRM	**3k**					1.00	.90	.84	.80	.94	.81	.76	.71
	4k					.81	.76	.71	.71	.75	.71	.68	.66
	5k					.92	.85	.79	.77	.84	.75	.72	.69
	6k					.81	.77	.75	.74	.76	.71	.71	.68
	7k					.92	.82	.78	.75	.81	.70	.71	.68
MAH	**3k**									.94	.87	.85	.82
	4k									.90	.79	.80	.75
	5k									.92	.80	.80	.77
	6k									.89	.77	.78	.74
	7k									.88	.76	.79	.75

Table 1: Mean similarity (*tau-x*) of consensus rankings generated by four algorithms for combinations of *n* alternatives ranked by *k* decision makers

Using the data from all 120 cells in Table 1, we examined whether the number of alternatives to be ranked (*n*) or the number of DMs (*k*) was related to the similarity of rankings. Across all 120 cells in Table 1, the correlation of *n* with mean similarity (*tau-x*) of rankings was -.51 ($p < .01$). As the number of alternatives to be ranked increased, the similarity of rankings generated by the four algorithms decreased. The correlation of *k* with mean similarity (*tau-x*) of rankings was -.21 ($p < .05$). That is, as the number of DMs increased, there was a slight tendency for the mean similarity of rankings to decrease.

CONCLUSIONS AND FUTURE RESEARCH

It might be helpful to view the similarity in rankings generated by different consensus algorithms from the perspective of psychometric theory. In psychometrics, reliability is often estimated by examining the correlation between two methods of rank ordering individuals (or objects). If two alternative approaches (e.g., two sets of scorers, two 'parallel' forms of a test) yield highly similar (correlated) results, this is viewed as evidence of their reliability. That is, when two scorers generate highly similar ratings (or rankings) of a group of individuals or objects, their ratings (or rankings) are said to be reliable. If two 'parallel' forms of a test generate highly similar rank orderings of individuals, they are said to be reliable (i.e., an individual can be expected to obtain nearly the same score regardless of which form of the test the individual is administered). In his classic text, Nunnally [16] notes that the level of 'satisfactory' reliability depends on how a measure is used. For basic research, Nunnally states that measures with reliability of .80 (e.g., the correlation between two 'parallel' forms of a test) are useful. In applied settings where an exact score on a measure determines whether an applicant will be accepted into a school, program, or organization, higher levels of reliability (above .90) are desirable. In this context, it is noteworthy that the similarity of rankings (*tau-x*) generated by WCM and BAK (.91) exceeds the level associated with satisfactory reliability in applied settings. The similarity of rankings generated by MAH and each of the other three algorithms (BAK, CRM, and WCM) exceeds .80, thereby indicating that rankings generated by MAH are quite similar to (but certainly not identical with) rankings generated by the other algorithms. In contrast, the rankings generated by CRM and WCM and by CRM and BAK (.74 and .76, respectively) are similar but cannot be viewed as interchangeable from a practical perspective.

The similarity (or lack of similarity) of consensus rankings generated by different algorithms (or rules) has consequences in applied settings. For example, Truchon [17] has illustrated (with 30 Olympic figure skating competitions between 1976 and 2002) that the choice of a consensus ranking rule or algorithm can have a real impact on the results.

As Jensen [12] noted, no consensus algorithm is likely to be free from criticism in all circumstances. Research that (a) examines the performance and properties of algorithms under real-world conditions where consensus controversies are likely to arise, and (b) explores user reactions to and acceptance of different algorithms will enhance the likelihood that at least some consensus algorithms will be adopted by DMs in applied settings.

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IMPLEMENTING GUIDED-INFERENCE FOR BAYESIAN INTELLIGENT SYSTEMS

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ABSTRACT

When an intelligent system is provided with insufficient information, its inference engine is unable to reach a conclusion in the targeted domain. In that case, inference-guiding process is needed to identify the missing information to lead inference to a conclusion. An inference process that is equipped with inference-guiding capability is called guided-inference. This paper discusses implementation of a quadratic guided-inference procedure for intelligent systems with Bayesian knowledge structure, which proves a conclusion after pursuing a few pieces of key information.

KEYWORDS: Inference engine, Reasoning, Inference-guiding, Bayesian network, knowledge-based system.

1. INTRODUCTION

A typical intelligent system has two major functions: doing logical inference and interacting with the environment. Logical inference is carried out in inference engine for generating facts logically implied by the existing data and the knowledge base. Interacting with environment include communicating with users, collecting information through sensors, and outputting the results through the system-environment interface. In many applications of intelligent systems, such as diagnosing, training, and real-time control, initial data are often incomplete, and no conclusion can be made based on those insufficient data. An intelligent system in that case would make hypothesis, identify the missing data, collect more information, and prove the hypothesis. In other words, an intelligent system should not be only a 'thinker' but also an 'investigator', as an inspector has to do investigation when initial clues for a case are not sufficient. An intelligent system for disease diagnosing, which makes judgment on the ailment that a patient may have, must also do investigations by, for example, asking the patient to provide more information on symptoms and selecting some examinations for the patient to do, when the information on hand is not sufficient to get any solid conclusion. The process of 'investigation' is called *inference-guiding (IG)* for an intelligent system. A good IG process would be able to identify a few relevant and key missing data in an efficient way, and lead inference quickly to a conclusion. A bad IG process, on the other hand, would ask irrelevant, costly, and silly questions, and retard the inference process. Therefore, an inference engine should be equipped with, in addition to logical inference, capability of *guided-inference* so that the intelligent system is able to seek smartly for key missing information when available data are not sufficient.

Probability was first considered in 1960s for representing uncertainty in a knowledge base [1]. A probabilistic system has showed theoretical strength in many applications with large knowledge bases [3]. The Bayesian network is a robust probabilistic structure for representing complex knowledge with uncertainties [2] [4]. An approach for inference-guiding in the probabilistic Bayesian network was developed by Wang in [5].

2. FUNDAMENTALS

An assertion is a statement that can bear one of the two truth values, 'true' or 'false'. An assertion is an *observable assertion (OA)* if its value can be obtained directly from an information source in the environment (a user or a sensor, for example). Examples are the assertions about the result of an X-ray examination, and assertions about the answers of patients to doctor's questions. An assertion is called *unconfirmed observable assertion (UOA)* if it is observable and its value is not yet known. UOAs represent the facts whose values are missing or unknown yet. An assertion is a *top-level-conclusion (TLC)* if it is in the domain that inference is aimed at. For example, possible diseases are TLCs in a disease diagnosing system; possible faults in an engine are TLCs in a diagnosing system for aircraft maintenance; and required operating adjustments are TLCs of a real-time piloting control system.

In a process of inference, *inference-guiding (IG)* picks some UOA and pursues their values if logical inference cannot reach any TLC. The new fact from inference-guiding is added to the pool of data. If a TLC is still not reached with the updated data, inference-guiding will pick another UOA. Total number of UOAs that are selected to pursue before a TLC is reached varies, depending on what UOAs are selected for pursuing and their sequence. Of cause, we want to reach a TLC after asking for as few UOAs as possible.

Inference on knowledge and facts with uncertainty is called *uncertain reasoning*. A TLC is reached when its certainty to be true is high enough. For example, the doctor would not inform a patient about the disease he may have unless, the probability of having that disease is significantly high. Usually, people use a 'threshold' value to represent the 'high enough' probability. Thus, a TLC is reached if its probability to be true is at or above the preset threshold.

The Bayesian network provides a robust structure for knowledge bases with uncertainties. A node in a Bayesian network represents an assertion. There is a directed arc from node A_j to node A_k if A_j is a premise of A_k. In other words, there is an arc from A_j to A_k if A_j has a direct influence on A_k. Each node is labeled with the probabilities of the values of the associated assertion. If assertion A_k is observable, then the prior probability of 'A_k to be true', denoted as $P(A_k=T)$, is given as the label. If A_k is an inferred assertion, then a list of full conditional probabilities of A_k is given as the label.

3. LOGICAL INFERENCE

The inference problem on the Bayesian network is NP-hard, which can be seen that the propositional inference, which is a special instance of uncertain reasoning in which each

probability is either 1 or 0, can be reduced to the satisfiability problem that is the first NP-complete problem.

To overcome the difficulties of computation complexity of exact inference, people have developed inexact but efficient algorithms for the Bayesian network. The *direct sampling approach*, a simulation method, is one of them. The probability of a TLC is derived from a sample of S trials of simulation, i.e., its probability is determined by the frequency that the TLC is true in those S trials. In each trial, the values of UOAs are generatedrandomly according their prior probabilities, and then propagated through the network according to the conditional probabilities provided in the Bayesian network. The sample frequency of the TLC being true is used as the approximation of P(the TLC = true).

The direct sampling approach is an efficient approach and the accuracy of the result can be controlled by adjusting the sample size S. It is a practical approach for inference in the Bayesian network.

4. INFERENCE-GUIDING

For the Bayesian network, Wang developed an inference-guiding criterion for selecting a most relevant UOA [5]. Let X represent the truth value A_x=true, $\neg$X represent the truth value $\neg A_x$=true (i.e. A_x=false). With this notation, we have P(X) for probability P(A_x=true), P($\neg$X) for P($\neg A_x$=true) or P(A_x=false), and P(K| $\neg$I, J) for P(A_k=true | $\neg A_i$=true, A_j=true) = P(A_k=true | A_i=false, A_j=true).

The *contribution index of truth value U to proving truth value T, $CI_{U\rightarrow T}$*, is defined as the difference between P(T|U) and P(T). That is, $CI_{U\rightarrow T}$ = P(T|U) − P(T) = P(A_t=true | A_u=true) − P(A_t=true). $CI_{U\rightarrow\neg T}$, $CI_{\neg U\rightarrow T}$, and $CI_{\neg U\rightarrow\neg T}$ are defined similarly. For example, $CI_{\neg U\rightarrow\neg T}$ = P($\neg$T|$\neg$U) − P($\neg$T) = P(A_t=false | A_u=false) − P(A_t=false). The contribution index $CI_{U\rightarrow T}$ measures how much it would help proving A_t=true if knowing A_u=true. Obviously, if A_u does not have any influence on A_t, then $CI_{U\rightarrow T}$ = $CI_{U\rightarrow\neg T}$ = $CI_{\neg U\rightarrow T}$ = $CI_{\neg U\rightarrow\neg T}$ = 0.

The *inference-guiding index (IG-index)* of truth value A_u=true towards proving A_t=true, *$IGI_{U\rightarrow T}$*, is defined as the product of $CI_{U\rightarrow T}$ and the prior probability of U. That is, $IGI_{U\rightarrow T}$ = $CI_{U\rightarrow T}$ * P(U). $IGI_{U\rightarrow\neg T}$, $IGI_{\neg U\rightarrow T}$, and $IGI_{\neg U\rightarrow\neg T}$ are defined similarly. $IGI_{U\rightarrow T}$ is interpreted as the contribution of A_u=true to proving A_t=true weighted by probability of A_u=true. Comparing to $CI_{U\rightarrow T}$, $IGI_{U\rightarrow T}$ takes both the contribution of A_u=true for deriving A_t=true and the prior probability of A_u=true into account. The IG-index has a unique property, $|IGI_{U\rightarrow T}| = |IGI_{U\rightarrow\neg T}| = |IGI_{\neg U\rightarrow T}| = |IGI_{\neg U\rightarrow\neg T}|$ for any A_u and A_t, which makes it suitable to be the criterion for inference-guiding, since at the time a UOA is selected, its value is not known.

5. IMPLEMENTING INTEGRATED GUIDED-INFERENCE

Logical inference and inference-guiding are two functions of an inference engine. Inference, or reasoning, is to do logical deductions to find out logical implications of the data. An inference

process is completed if a TLC in the target domain is proved. If no TLC is reached, inference guiding function is kicked on to identify the missing data. After a UOA is selected, its value is pursued through the environmental interface, such as from sensors, or from the user or an information source. Having obtaining the value of the UOA, the reasoning function is resumed to check whether a TLC is reached.

Integrated TLC-Oriented Guided-Inference Process (ITGI)

Step 1. Inference:

1.1. For each $i \in \{TLC\}$, calculate $P(A_i)$ by using Subroutine INFERENCE-SAMPLING with c=i.

1.2. If there is $k \in \{TLC\}$ such that $P(A_k) \geq h$, Stop, - the inference is done with A_k being the conclusion; otherwise, go to Step 2.

Step 2. Select a UOA:

2.1. Pick up A_t such that $t \in \{TLC\}$ and $P(A_t) = MAX_{i \in \{TLC\}} P(A_i)$.

2.2. If {UOA} is empty, then Stop, - no TLC with certainty level equal to or higher than the threshold h can be derived.

2.3. Calculate $|IGI_{I \to T}|$ for each $i \in \{UOA\}$:

(a) Calculate $P(A_t \mid A_i)$ by using Subroutine INFERENCE-SAMPLING with c=t and A_i=true.

(b) $|IGI_{I \to T}| = |(P(A_t \mid A_i) - P(A_t))\, P(A_i)|$.

2.4. Pick a UOA A_u such that $|IGI_{U \to T}| = MAX_{A_i \in \{UOA\}} |IGI_{I \to T}|$.

Step 3. Pursue the value v_u of A_u from an information resource through the environment interface.

Step 4. Reset the system and go back:

4.1. Set A_u's value to v_u, and let $\{UOA\} = \{UOA\} \backslash \{A_u\}$

4.2. Go back to Step 1.

#

Subroutine INFERENCE-SAMPLING.

Let A_c be the targeted TLC. Let $ACCT(A_c)$ denote a counter of A_c=true, which is initially zero.

Phase 1. Sampling.

Repeatedly do the following three steps for S times.

1.1. Mark all UOAs:

For each UOA A_k whose value is known, mark A_t with $V(A_k)$ = its value;

For each UOA A_k whose value is not known, generate its value $V(A_k)$ according to its prior probability $P(A_k)$, mark it with $V(A_k)$.

1.2. Mark all other assertions:

Do the following until all assertions are marked.

For an assertion A_k whose immediate predecessor assertions in the Bayesian network are all marked, generate A_k's value $V(A_k)$ according to the conditional probabilities provided in the Bayesian network, mark A_k with $V(A_k)$.

1.3. If $V(A_c)$=true then $ACCT(A_c)=ACCT(A_c)+1$.

Phase 2. Calculate $P(A_c)=ACCT(A_c) / S$.

#

Note that subroutine INFERENCE-SAMPLING is used for inference as in Step 1, as well as for calculating $|IGI_{I \to T}|$ for inference-guiding in Step 2. When in inference-guiding, INFERENCE-

SAMPLING is used to calculate $|IGI_{I\rightarrow T}|$ for each UOA A_i, and its inputs are currently known values of OAs, the simulated value of UOA A_i, and the selected TLC A_c.

6. EXPERIMENTS ON GUIDED-INFERENCE

We tested the guided-inference approach ITGI in computational experiments. Computer language C was used for coding in this experiment project, with Microsoft Visual C++ 6.0 as the compiler. Knowledge bases are randomly generated with parameters of number of assertions, number of correlation sets of assertions, number of UOAs, and number of TLCs. Prior probability of each UOA and conditional probabilities associated with each set of correlated assertions are also randomly generated. To evaluate the guided-inference approach addressed above, we also developed computer codes for two other inference-guiding approaches that are used in currently intelligent systems to guide inference: *pure random approach* and *back-chaining approach*. By the pure random approach, next question is selected randomly from the current UOAs. By the back-chaining approach, the UOAs that are correlated to a selected TLC are identified first, then the next question is selected from that set of UOAs.

A knowledge base is composed of sets of related assertions, in which each set is called a '*clause*'. Each application is represented by a set of 'true/false' values, each for a UOA, which is called a '*scenario*'. There are typically many scenarios associated with a knowledge base, as in disease diagnosing, the knowledge base represents doctor's knowledge, while a set of 'true/false' values of UOAs represents the symptoms of a patient. In experiments, we used a 'probability threshold', 0.95 for example, as an indicator for a TLC being proved. That is, if a TLC's probability is 0.95 or higher, that TLC is proved. It is possible that no TLC reaches the threshold even after asking about all UOAs in a particular scenario. In our experiments, we only counted the cases in which a TLC is reached. We compared ITGI with the pure random approach (*Rand*) and the back-chaining approach (*BC*) on 700 knowledge bases / scenarios. Table 1 below shows the average numbers of UOAs asked before a TLC is proved by the three inference-guiding approaches.

Table 1. Comparison of three inference-guiding approaches

knowledge base / Scenario				number scenarios tested	number scenarios in which TLC proved	avg. number of UOAs asked		
# of clauses	# of assert'ns	# of UOAs	# of TLCs			**ITGI**	**Rand**	**BC**
12	16	8	3	100	84	3.2	6.4	5.7
20	30	13	6	100	90	4.6	11.3	10.1
24	32	15	7	100	92	4.7	12.1	10.6
40	60	32	10	100	85	7.0	26.9	24.4
48	64	34	10	100	76	7.8	27.5	24.3
96	128	68	20	100	88	15.5	57.6	52.1
192	256	136	40	100	77	21.9	106.5	98.0

The experiments showed that ITGI asked about significantly fewer UOAs to prove a TLC, comparing to the other two approaches. The inference-guiding mechanism embedded in ITGI is indeed capable of leading inference to a conclusion 'smartly' and quickly.

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MULTI AGENT STRATEGIES FOR DECISION SUPPORT APPLICATIONS

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ABSTRACT

Our results confirm that information managers designing machine based decision support systems should employ a multi-agent strategy that includes agents from diverse cognitive classes. In this research we employ a set of intelligent agents that *'think differently'* and cooperate to produce a group decision. We are able to reduce the generalization error in two bankruptcy detection data sets by 10-50% with this strategy. Reductions of this magnitude in high volume, high value, and repetitive decision environments are extremely significant; typically error reductions of even a fraction of a percent are welcome. We further show that diversity trumps ability; that is, as group diversity increases, the generalization error decreases, and the prominence of the most capable expert in the group diminishes.

INTRODUCTION

The attempt to identify more capable agents (or models) and thereby increase the decision accuracy has been a significant thread of research in decision support applications. One of the first decision agents to be employed was multivariate linear discriminant analysis (MDA), a method that assumes a multivariate normal distribution (Altman et al., 1968). Logistic regression or logit agents were then investigated to overcome the perceived restrictive assumptions of MDA (Desai et al., 1996; Zurada et al., 1999). These were followed by adaptive nonlinear models including neural networks, genetic algorithms, and support vector machines (Altman et al., 1994; Bertels et al., 1999; Brockett et al., 1997; Coats and Fant, 1991; Davalos et al., 1999; Desai et al., 1996; Glorfield and Hardgrave, 1996;, Kun et al., 1996; Lacher et al., 1995; Piramanthu, 1999; Salchenberger et al., 1992; Tam and Kiang, 1992; Yang et al., 1999). Recent research has focused on group decisions formed from the cooperation of a committee (or ensemble) of multiple agents. The cooperation of multiple agents reduces the variance of the decision error and in some cases the bias term as well. In almost all cases these committees are comprised of agents from a single cognitive class that is agents with a common algorithm for finding problem solutions.

The hypothesis of this research is that the accuracy of decision support applications can most effectively be increased by a multi agent strategy including agents from different cognitive classes. We prove this hypothesis with an experimental design that controls for committee diversity levels including cognitive diversity (variation in the internal representation of the problem and the heuristics used to find improved solutions), content diversity (variation in the learning examples available to each agent), and ability diversity (variation in the agent's capability to form complex representations of the problem). We use bankruptcy data sets in this research since this is a critical decision environment characterized by high volume (there are tens of thousands of firms to monitor), high significance (there are millions of dollars at stake), and repetitive activity (requires constant updating and monitoring). An improvement in decision accuracy of even a fraction of a percent translates into significant savings for the credit industry.

MULTI AGENT STRATEGIES FOR DECISION SUPPORT

The concepts of multi-agent information systems (Sikora & Shaw, 1998) and cooperative intelligent systems (Pendharkar) have recently been proposed for decision support applications. In this context, an agent is defined as a stand-alone unit participating as a component of the overall information system (Sikora & Shaw, 1998). Multi-agent research distinguishes between competitive synthesis (where agents work asynchronously on the same problem and the best agent solution is the group solution) and cooperative synthesis (where the group decision is a function of the agents' individual performance measures) (Pendharkar in press). Pendharkar empirically demonstrate the utility of a multi-agent intelligent system for production scheduling. Kiang confirms the validly of multi-agent systems concluding that the design of systems in which several methods are employed increases the reliability and consistency of the decision. (Kiang 2003).

There has been considerable research effort during the past decade to develop accurate decision support systems, what we would characterize as competitive synthesis, the search for ever more accurate agents. For example, (Wilson and Sharda 1994) compared the predictive capabilities for firm bankruptcy of neural networks and multivariate discriminant analysis; they conclude that neural networks predict firm bankruptcies significantly better than discriminant analysis. Tam and Kiang, 1992 investigated a neural network to identify bank defaults. They compare in a competitive manner the following agents: neural network, linear discriminant analysis, logistic regression, k-nearest neighbor, and recursive partitioning trees. Their results show that the neural network is a promising agent for evaluating bank default in terms of predictive accuracy, adaptability, and robustness. Zhang et al. also concluded that neural networks are significantly better than logistic regression in bankruptcy prediction (Zhang, Y. Hu et al. 1999). Similar competitive studies were conducted by (Altman et al., 1994; Bertels et al., 1999; Brockett et al., 1997; Coats and Fant, 1991; Davalos et al., 1999; Desai et al., 1996; Glorfield and Hardgrave, 1996;, Kun et al., 1996; Lacher et al., 1995; Piramanthu, 1999; Salchenberger et al., 1992; Yang et al., 1999).

The concept of competitive synthesis continues in bankruptcy decision support research with the investigation of new architectures including hybrid models and support vector machines. Serrano-Cinca proposed a decision support system for financial diagnosis based on Self Organizing Feature Maps which project financial ratio information from a high dimensional space to a two dimensional map. In this map, exposed companies are represented close to one another. The Self Organizing Feature Map is compared with linear discriminant analysis as well as with the multilayer perceptron neural network models (Serrano-Cinca 1996). Tsakonas et al. demonstrates the efficient use of hybrid intelligent systems based on genetic programming for solving the bankruptcy detection problem (Tsakonas, Dounias et al. 2006). Huang et al. introduces a relatively new machine learning technique, support vector machines, to the bankruptcy detection problem in an attempt to provide a model with better explanatory power. The authors obtained prediction accuracy around 80% for both multilayer perceptron neural network and support vector machine agents using data from the United States and Taiwan markets. (Huang, Chen et al. 2004). Lee et al. developed a hybrid neural network for bankruptcy prediction and concluded from Korean bankruptcy data that the hybrid neural network is a promising agent for bankruptcy prediction in terms of accuracy and adaptability (Lee, Han et al. 1996).

SOURCES OF AGENT DIVERSITY

This research is structured with three major sources of agent diversity. The first source of diversity is diversity in learning content caused by the perturbation of the training sets of the bagging algorithm. For unstable agents, the training data perturbations result in agents with different parameter estimates. The second source of diversity is generated by the variation in agent ability as the agent's architecture is varied. For example, as the MLP hidden layer neurons vary from 2 to 10, the capacity of the agent to represent complex decision boundaries increases. This form of diversity, which we refer to as intraclass diversity, results from agents that think the same but have more or less ability to represent complex decision boundaries. The third source of diversity is created when agents from different cognitive classes cooperate to reach collective decisions; we refer to this as interclass diversity. Each source of diversity will be discussed briefly in the following subsections.

Bagging and Content Diversity

The bagging algorithm is the most common method of diversity generation today. It functions by varying the learning content available to individual ensemble members. Each ensemble member has some specific learning examples emphasized through duplication in its bootstrap replicate, while other learning instances are missing. For unstable agents, these differences in learning content result in significantly different parameter estimates and potentially a diversity of member decisions that create more accurate collective decisions.

Agent Architecture and Ability Diversity

For the KNN, KD, MLP, and RBF cognitive classes, it is possible to alter the capacity of the agent by the choice of architecture. The term 'capacity' refers to a concept from statistical learning theory that refers to the representational abilities of the agents (Vapnik, 1998). High capacity agents can form more complex decision boundaries and consequently fit the training data more closely (possibly at the expense of overtraining and failing to generalize to the test data). Agent capacity is, in turn, related to the concept of shattering. A classification model C(T) can shatter a set of data points X_n, if, for all assignments of labels to those data points; there exists a T, so the model C(T) makes no errors evaluating that set of data points. The capacity of the agent can then be measured by the Vapnik Chervonenkis (VC) dimension. The VC dimension of C(T) is the maximum h such that some data point set of cardinality h can be shattered by C(T). The VC dimension h can then be used to estimate an upper bound on the test error of C(T) with probability 1-?, where h is the VC dimension and N the size of the training set. Higher capacity agents can form more complex decision boundaries; lower capacity members form simpler decision boundaries.

Cognitive Classes and Cognitive Diversity

This source of diversity results from the inclusion of agents from different cognitive classes, a form of cognitive diversity. In this context, cognitive diversity implies that the different agents think differently. i.e., they form different internal perspectives of the problem and use different heuristics to achieve improved solutions [Hong and Page, 2004].

RESEARCH METHODOLOGY

Bankruptcy Data and Partitions

We constructed our bankruptcy data set, herein referred to as U.S. Bankruptcy, from Standard and Poor's Compustat database. There are a total of 329 observations in the data set with 93 bankrupt companies and 236 healthy companies. We repeat the experimental design on an independent database

of Spanish bank failures (Serrano-Cinca, 1997) to assess if the findings of the U.S. Bankruptcy data generalize to other bankruptcy data sets. The Spanish Bank data are more focused, containing only 66 cases with 9 financial ratios. Bank failures in this data occurred during the period from 1977 to 1985.

The data sets are partitioned into a learning set with 70% of the examples, a validation set with 15%, and an independent holdout test set with 15%. A total of i=100 different sets of partitions are created by randomly shuffling the data rows. These iterations allow us to contrast generalization errors between the ensembles formed at different levels of model diversity and to detect relatively small differences in accuracy. A total of 100 bootstrap replicate training sets are then formed from each of the 100 learning partitions for a total of 10,000 training replicates. The bootstrap replicates are formed by sampling with replacement from the original training set partition. This provides diversity in the training set, which may potentially decrease the ensemble generalization error.

Controlling for Ensemble Model Diversity

Each ensemble is designed with a total of 34 group members. The generalization error of the collective decisions reached by the ensemble members is measured at several controlled levels of model diversity. We measure the level of model diversity by simply counting the number of unique models in the ensemble. We use the term "homogeneous ensemble" to describe those ensembles whose membership is limited to replications of a single unique model. These are the least diverse ensembles limited to only the variability created by the bootstrap replicate training set. In addition to the homogenous ensembles, we create ensembles with 4, 8, and 12 unique models. At each level of model diversity, a total of 1,000 ensembles are formed; each of these ensembles is formed with models randomly selected without replacement from the population of 22 unique models. To fill each ensemble with 34 group members, the randomly chosen models are replicated a number of times. For example, an ensemble with 4 unique models is formed with 9 replicates of the first randomly selected model, 9 replicates of the second, 8 replicates of the third, and finally 8 of the fourth model. Each time a unique model is replicated in an ensemble, a different bootstrap result is randomly selected without replacement from the population of 100 bootstrap replicates.

RESULTS OF DIVERSITY STRATEGIES

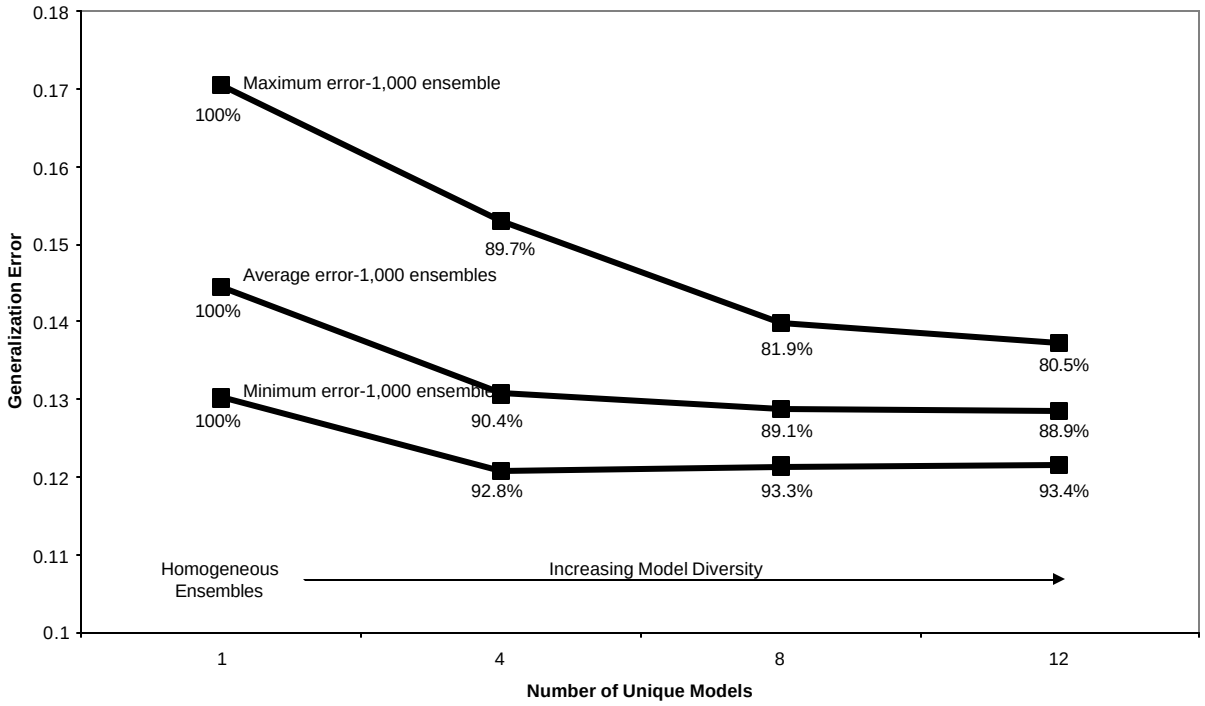
The generalization error of ensembles formed with controlled levels of model diversity varying from 1-12 unique models is depicted in Figure 1. Each result is based on 1,000 random ensemble formations for each of the 100 data partitions, with variations in both the unique models employed and the bootstrap replicate used to train the model. We report the maximum ensemble error, the average ensemble error, and the minimum ensemble error for each experimental condition.

The homogeneous ensemble, comprised of a single classification model, is used as a baseline in this study for contrasting the accuracy of ensembles formed with controlled levels of model diversity. It is clear from Figure 1 that increasing the model diversity results in ensembles with significantly lower generalization errors. The average generalization error for the homogeneous ensemble is 0.1446. The least accurate of the 1,000 homogeneous ensembles has an error of 0.171, while the most accurate ensemble achieved an error of 0.130.

As the number of unique models in the ensemble increases to 4, 8, and 12 randomly selected unique models (Figure 1), both the maximum and average ensemble error decrease monotonically. With 4 unique models, the maximum ensemble error is reduced from 0.171 for the homogenous ensemble to 0.153, a reduction of 10.3%; the average ensemble error is reduced from 0.1446 for the homogenous ensemble to 0.131, a reduction of 9.6%. If we compare the homogenous model with ensembles of 8

unique models, the maximum error is 0.140, an 18.1% reduction; the average error is 0.1289, a 10.9% reduction. The improvement in generalization error from 8 to 12 unique models is much more modest, but continues to decline for the maximum and average error. The maximum error for 12 unique models is 0.1373, an overall reduction from the homogenous model of 19.5%. The corresponding average error is 0.1285, an 11.1% reduction.

Figure 1: Ensemble Generalization Error
US Bankruptcy Data

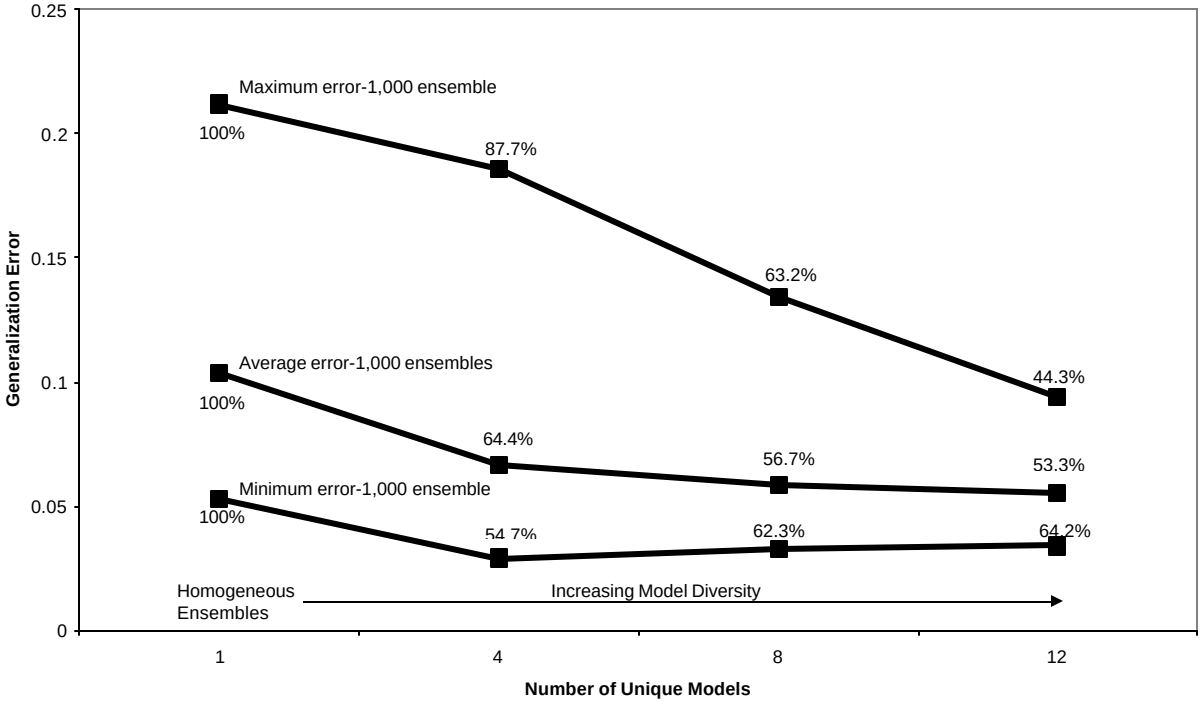


The minimum ensemble error measures the most accurate ensemble from each set of 1000 randomly formed ensembles. Figure 1 indicates the minimum ensemble generalization error behaves somewhat differently than the maximum and average error. At 4 unique models, the minimum error is 0.1208, a 7.2% reduction from the minimum homogenous ensemble error. At 8 and 12 unique models, the minimum ensemble error increases slightly to 0.1214 (6.7% reduction) at 8 models and to 0.1216 (6.6%) at 12 models. The minimum ensemble error occurs at 4 unique models and does not decline as model diversity increases beyond that point. Figure 1 also confirms that the variability of ensemble results decreases significantly as the number of unique models increases. The range between the maximum and minimum error (0.04) for the homogeneous ensemble decreases monotonically, with increasing model diversity (0.016) at 12 unique ensemble models.

The Spanish Bank results strongly confirm the earlier conclusions from the U.S. Bankruptcy data. The effect of model diversity on the collective decision accuracy of the Spanish Bank data is much more pronounced, with error reductions ranging up to 50%. Again, the largest variation in results occurs with the homogeneous ensembles. The average error of all homogeneous ensembles is 10.34%, with the most accurate ensemble achieving a 5.30% error and the least accurate a 21.20% error. These errors fall dramatically as the model diversity in the collective decision is increased from 1 to 4 unique models. The average error of all randomly formed collections is 6.66%, or 64.4% of the homogeneous average; the most accurate ensemble has a generalization error of 2.90% (54.7% of the homogeneous case), while

the least accurate ensemble generalization errors is 18.6% (87.7% of the homogenous case). The accuracy of the average and least accurate collective decisions continues to decrease as model diversity increases to 8 and 12 unique models. The average error decreases to 5.51% at 12 unique models, almost half of the homogenous average. The least accurate ensemble decision decreases to 9.4% at 12 unique models (44.3% of the homogenous case). The error of the most accurate ensemble increases slightly as model diversity increases beyond 4 unique models (2.9% to 3.3% and 3.4% respectively for 8 and 12 unique models). This pattern was also observed in the U.S. Bankruptcy data.

Figure 2: Ensemble Generalization Error
Spanish Bank Data



These results show a marked advantage to designing bankruptcy detection ensembles with model diversity. There is a statistically significant reduction in generalization error between the homogeneous ensembles and those ensembles randomly constructed with levels of 4, 8, and 12 unique models ($p < 0.000$ for all cases). We show that expected error decreases monotonically as the level of diversity increases, with small improvements beyond 8 unique models. The maximum error (worst case scenario) declines most steeply at 12 unique models, with close to 20% reduction. The most accurate ensembles have approximately 4 unique models.

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References are available upon request from David West

TOWARDS BALANCING THE RIGOR AND RELEVANCE DICHOTOMY IN INFORMATION SYSTEMS: AN EPISTEMOLOGICAL UNDERSTANDING.

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ABSTRACT

The debate on rigor and relevance raises important questions for IS discipline. The dominant paradigm of IS research has the overbearing of rigor, with a focus on research methods employed in line of natural sciences. In due respect, strict adherence to rigor might overlook the practical implications and endanger the relevance of IS research. We feel that contemplating on the foundations of this field would be one approach to contribute to this debate. In this paper, the emphasis on rigor and relevance is evaluated through underlying epistemological considerations. A discussion on existing IS paradigms is presented with their respective implications on rigor and relevance.

Key words: **Rigor, Relevance, IS, Positivism, Intepretivism**.

INTRODUCTION

The duel between rigor and relevance has been generated in behavioral sciences literature for a while (Shrivastava, 1987; Thomas, et. al, 1982; Ruback, et. al., 1988).. However, seldom have any of these earlier debates reflected on this dichotomy from a philosophical perspective. The genesis of the debate in our field (IS) lies in its questioning of the construction and the evolvement of Information systems (IS) as an academic discipline. The discussion through various academic journals (Pearson, 2005; MISQ, Vol. 3, 1999; Truex, 2001; Amaravadi, 2001; Farhoomand and Drury, 1999 and Westfall, 1999) have offered criticisms and subsequent remedies to level the balance between the divide of rigor and relevance (Benbasat & Zmud, 1999). On the other hand, there have been few staunch supporters, reiterating the good health of 'relevance' in the discipline (Gray, 2001). However, there was also an increasing feeling within the community that 'relevance' was being marginalized. For instance, "the famous Minnesota experiments (Dixon, 1977) substantially increased the rigor, but at the same time the practical relevance of this type of IS research decreased" (Klien, 1999).The discussion on the waning of relevance is ensconced in several arguments. These could be summarized briefly as:

- Relevancy of research publications must encompass implications that are implementable in the real world. Not only that they must be capable of stimulating critical thinking and synthesize an existing body of work. Also, there are other factors that contribute to declining relevance. These factors are lack of cumulative tradition, complexity in research because of dynamism of Information technology and Political factors. (MISQ. Vol. 3, 1999)

- The over emphasis on rigor, has now been explained from a view point of "gaining acceptability and respectability within the business school" (Benbasat & Zmud, 1999). In addition, the tenure process has also demanded more rigors (Bombast & Weber, 1996).
- To save the irrelevance of IS research, there are tangential suggestion offered such as emulating medicine and law rather than other business disciplines. Adopting more practioners oriented journals, and course redesign in schools (Davenport & Markus, 1999).
- In another light, some scholars comment that researchers confine themselves to specific methodologies for problem solving. Few are inclined to perform the arduous task of attempting to determine problems that are potential mechanisms for theoretical and rigorous insights into practice (Ivari, 1999).

If one acknowledges the current model for IS, has evolved to the notion of a of a social system (Hirschheim, 1991), then the relevance of the epistemologies that are practiced could be questioned as - What is then the function of rigor/ relevance with respect to the inquiry systems? How could/should we define IS as a science? We attempt to focus on these questions in the following sections.

CONCEPT OF INFORMATION SYSTEMS (IS) AS SOCIAL SYSTEM

In early days, computers were used primarily for accounting purposes. This notion of IS emulated a production process in a factory: input and output. This was referred to as a production model of IS. The emphasis was on data processing and data automation. The database technology enhanced this *production model of IS* to encompass larger transaction based systems including various business function such as: accounting, sales, personnel, payroll etc. There was now a need to make a key distinction between data and information. This gradually gave rise to the *interactive model of IS*, such as the Decision Support System (DSS), Expert Systems (ES), where the users are no more passive recipients of the system, rather they interact with the system. The main objective was to increase the efficiency and effectiveness of decision makers. These independent systems (DSS, ES), evolved into *networked model of IS*, such as ERP systems, EIS systems. This reflected interconnectedness amongst business functions and various management levels. With the advent of internet, growth of e-commerce, a new concept *of inter-organizational model of IS* come into being. This integrated people, processes, assets and systems across geographical boundaries and amongst many organizations. Such a model highlighted the need to study organizational, social, political, legal and personnel issues rather than just technology related issues. This shift gave impetus to the thought of viewing IS as not just 'processing data' but also as a mediator of communication and collaboration amongst people. In other words, IS is understood as a *social system* that uses information technology. In fact, many researchers have claimed that IS should be viewed as a social system; a component of the larger domain comprising language, linguistics and social interaction (Boland, 1985; Markus & Robey, 1986; Klien & Hirschheim, 1983; Lyytinen & Hirschheim, 1988). Further, since IS straddles multitude of disciplines, it has often been referred to as multi-discipline and multi- paradigmatic.

INFORMATION SYSTEMS (IS) AS A SCIENCE

The traditional natural science bred positivistic manifesto of science suggests that for something to be considered scientific it must use agreed set of conventions. Additionally, scientific approaches that have arisen from scientific tradition have been characterized by repeatability, reductionism and refutability (Galliers, R.D. 1991). Moreover, since IS is fast being accepted as a social model, then perhaps, this perspective of science is quite restrictive. Therefore, a scrutiny of positive science appears to be in order, to reconcile its limited appeal in the present context of IS phenomenon. This scientific method may be more appropriate for the natural sciences but not necessarily for the social sciences. Therefore, scientific research in IS could be more appropriately defined in terms of problem solving (Lauden 1977, Kuhn 1970), since this simply becomes a problem solving activity incorporating certain conventions. With this posture, the emphasis shifts away from statistical significance and related aspects, thus alleviating the problems associated with research methodologies. One is looking for an appropriate way to solve a particular problem (Lauden, 1977). According to Snyder (1978): "Science is something people do. It is not a particular set of assertions or theories, but a set of activities that may or may not produce organized theories." In this regard, we move away from the positivist science and adopt more broader and permissible understanding of science and then evaluate the appropriateness of the methodologies followed in IS research. In the following section, the dominant epistemologies of the field are described briefly.

A BRIEF DISCUSSION OF THE RELEVANT SCHOOLS OF THOUGHT

Positivism

Positivism asserts that there must be a unity of scientific method. They emphasize upon search for Humean causal relationships and belief in Empiricism. Science and its processes are value free and that the foundation of science is based on logic and mathematics (Hirschheim, 1985). The positivist also aims to explain, and subsequently predict external reality, implying that people are not constructors of their physical or social reality. Social science, however, has long criticized this positivistic approach to science. Despite the criticism, positivism continues to dominate the social science research. Positivist approaches assume that social science is at a point of development where methods and techniques appropriate to explanation and prediction may be employed and that social complexity can be ignored. The debate about positivism has illustrated the limitations of traditional research methods when applied to many social science problems. An alternative path would employ qualitative and inductive approaches (Smith 1990).

Interpretivism

Interpretivism asserts that reality, and our knowledge of it, are social products. The world is not a fixed grouping of objects, but rather is a continually evolving social process that is an extension of human consciousness and subjective experience (Orlikowski and Baroudi 1991). Social research aims to understand how social group members create their realities and give the realities meaning through their participation in social processes. Organizations and groups do not exist separate from humans and therefore are impervious to pure positivistic attempts to objectively and universally comprehend, characterize, or measure. The interpretive researcher attempts to derive constructs from the field by in-depth examination of/and exposure to the phenomenon of interest. The social researcher's primary

endeavor is to describe, interpret, analyze, and understand the social world from the participants' perspective. In doing so, the researcher can never assume a value-neutral stance; the researcher's prior assumptions, beliefs, values, and interests always intervene to shape the investigation (Orlikowski and Baroudi 1991). The world can be characterized by an interpretivist view; it is socially constructed, it permits the existence of multiple realities, and scientific research is both time and context dependent. "The interpretivist tragedy is to fail to recognize that research communication, in the traditional form, is positivistic. On the other hand, the positivist tragedy is their endeavor to operate on the assumption that the world is also positivist" (Fitzgerald and Howcroft 1998).

Criticalism:
A fundamental assumption of this philosophy is that social reality is not only constructed and created by humans but also possesses objective properties that tend to dominate human experience. There are two principle ideologies of this philosophy. One, that social reality is historically created thus people, organization and societies at large are not confined to exist in a particular state. The other, is that objects cannot be treated in isolation. Any particular element exists in context of totality or relationships, of which it's a part. The role of the researcher with respect to theory and practice is to historically bring to light the restrictive conditions of 'status quo', thereby motivating change in social relations and practice (Chua, 1986). Criticalism recommends researchers adopt a holistic approach while observing different entities and social phenomenon (Jonsson 1991). In a social system, an entity can only exist as a part of a larger system and can never survive on its own. Since social reality is historically created, the knowledge of such systems can only be gained by observing the social and historical practices. A longitudinal study rather than cross-sectional design would serve the purpose of studies undertaken from this perspective.

Pluralism:
An alternative to a forced selection between positivism and interpretivism is to adopt a pluralist strategy. Pluralism allows different paradigms to be applied in a research situation. Further, it allows a contingent toolbox approach where different methods with complementary strengths could be used as deemed appropriate. Even though there may be incommensurability at the paradigm level, some accommodation may be possible at the lower ontological, epistemological, methodological, and axiological levels. Thus, methodological pluralism has been recommended as an appropriate strategy in practice. Combining diverse research methods with a view to maximizing their complementary strengths is clearly worthwhile (Fitzgerald and Howcroft 1998). The dominant and the alternative philosophies mentioned earlier are discussed to evaluate the position of 'rigor' and 'relevance' in IS. We seek to comprehend what guided both these positions and whether there is a need to understand them in other philosophical light.

RECASTING RIGOR AND RELEVANCE

The current fragmented approach and lack of consanguinity within these concepts is still shaping much of current research. A quick recap of the characterization of Information systems reveals that, it is increasingly being accepted as a multi-disciplined social system that processes knowledge. This is far from its almost puritan association with the natural sciences that was purported earlier by the appellation of 'production model'. Additionally, the scientific approach to research in the field is more allied with the notion of science being a convention, related to societal norms, expectations and value. Therefore,

scientific inquiry can be seen as a problem solving process that has less to do with specific methods and more with practical solutions.

The question that arises is that what is the significance of relevance and what is the epistemological shift, if there is any? To understand this, it is essential to accept the new face of IS. Once we accept this, then it is graspable that research is lacking relevance in the field, for it has not addressed the endemic questions germane to the understanding of current phenomenon of IS: a social system. This necessities that IS researchers investigate sociological phenomenon in different contexts. Further, the positivist inquiry system is also severely challenged. In essence, we have an interpretivist school that is emerging in the discipline. However, if one looks from the methodological level; the discipline is in a cross-fire, which is, subscribing to both positivism and interpretivism. There is dominating implementation of quantitative techniques with confirmatory analysis: a positivist approach. These are meshed with exploratory analysis (co-citation analysis, meta-analysis) and field experiments that mostly subscribe to the Interpretivist school. In fact, according to Alan Lee (1999): "In our experience as authors and editors we have found that some readers inappropriately use positivist criteria to judge Interpretivist intense research, and others inappropriately use Interpretivist criterion to judge positivist intense research".

Clearly, both these traditional school of thoughts are incapable of inquiring into the phenomenon of IS by themselves independently. Can we then use criticalism or perhaps pluralism ? With criticalism, the limitation is the 'status quo' condition that must be brought to light. In the case of IS, this is not necessary. Historically, it has been understood that it is a dynamic discipline. Hence, there is little scope of stasis. Therefore, casting IS under the school of criticalism could be challanging.

With the paramount importance of the human and social dimensions that became legitimate research topics within the field of IS. Two main options were open to IS researchers: use their traditional tools or borrow new ones from the various disciplines of the human and social sciences (Landry and Banville 1992). A disciplined methodological pluralism for Information Systems is a reasonable position. Much can be gained if a plurality of research perspectives is effectively employed to investigate information systems phenomena. The larger encompassing view of IS concerned with social, organizational, and individual factors has emerged, leading to greater complexity, imprecision, and ambiguity. This in turn requires new paradigms for IS research. Thus, methodological pluralism, allowing multiple paradigms for MIS research, should be encouraged (Mingers 2001; Alive and Carlson 1992).

Clearly, singularity of epistemological foundation applied to the discipline is unrealistic. From another viewpoint, if we treat the inquiry into IS at par with other professions such a medicine, law or architecture, then the inquiry process does not quite follow on the same lines as that of natural sciences. Inquiry in these disciplines follows the goal of producing knowledge on how to satisfy real world needs through a process of intervention. This does not mean that the natural science approach is irrelevant to practice but that the way followed by traditional approach might be poor in the scenario that exist now. It is time to use a newer approach, such as the inquiry system in the professions (Lee, 1999).There is a need to seriously explore pluralism and its appropriateness for IS based on the characterization of the discipline and the need to move away from the natural science inquiry mechanism and adopt an appropriate system that is more akin to 'professions'.

This leads credence to the validity of the relevance in the discipline and that there is no demanding requirement for a straight-jacket comparison of relevance versus rigor. Rather, rigor now needs to be

redefined, in terms of the dominant epistemology of intepretivism and perhaps in the more suited one of pluralism.

CONCLUSION

The character and nature of Information has evolved considerably. From the earlier notion of a simple production oriented system having just an input and output function with no place for humans, to a human centric view of a social system, that is not only buttressed by the classical computer science discipline but also by other fields such as sociology, behavioral science, political science, linguistics, etc. This revised understanding helps us define the field and its research. This, in turn makes it necessary to recast the definition of science and scientific methods to a more encompassing one, in order to conduct more rewarding research in the discipline. Therefore, the field of IS cannot be simply looked upon from the philosophy of positivism. Rather, it should be looked from the lens of pluralism. Till the time a consensus is reached amongst the community of researchers, interpretivism could serve as a bridge. Relevance then, can be understood as an inquiry into the phenomenon, with the assumption that Information systems is viewed as a social process. Rigor, will have to be understood as other than the methodological rigor dictated by the natural sciences. In closing remarks, "Efficiency and rigor are means. They support objectives. The grave danger is that the power of efficiency and the rigorous becomes such that, the less efficient and rigorous, however important, cannot compete and so cannot be heard" (Verma, 1988).

References: Available on request from first Author

Creating an Environment That Facilitates Knowledge Sharing in a Teaching Hospital

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Abstract

Hospitals need to encourage doctors to share information and knowledge. Medical knowledge is most valuable when it is collective. Medical knowledge is constantly updated as physicians learn, gain experience, have insights, and share ideas.

This paper looks at creating high performing teams of physicians and facilitating communication and collaboration. In light of recent pandemics, this paper also considers the need to share knowledge across organizations throughout the world.

Introduction. The first patient with severe acute respiratory syndrome (SARS) died in Toronto, Ontario, Canada on March 5, 2003. The index patient, who had recently visited Hong Kong, passed along the new variant corona virus to her family there. Her son died on March 13, 2003. Since Taiwan is geographically near to China and Hong Kong, areas with populations of 23 million, the SARS outbreak took off on April 23, 2003, at a municipal hospital in Taipei. The first patients went to National Taiwan University hospital's emergency room (ER).

During the outbreak, the biggest challenge was deficiencies in personnel. For instance, any doctor could volunteer to care for SARS patients, including emergency department

physicians, general internists, family physicians, surgeons, and anesthesiologists. The ratio of patients-to-physician varied from five to 10 SARS patients per physician. At this hospital, it had traditionally taken up to three and half weeks to initiate a patient into the system. Because of the epidemic, the hospital developed a system that enabled personnel to start working within 24 hours of the emerging epidemic. This system had to include 1) prominent communications and place a premium on the relationship between public health staff and hospital personnel, 2) an information technology platform that led to flow of data between jurisdictions, and 3) Forums and meetings held daily to exchange information.

Williams [1] stated interpersonal trust plays a critical role as a social resource, and can facilitate cooperation and empowered coordinated social interactions. Trust speeds informal cooperation and cuts down negotiation costs. It is especially valuable for cross-functional teams. There are two major components of trust: competence and responsibility.

This work is based on an analysis of a theoretical model of trust [2] and is designed to contribute to understanding the nature and functioning of interpersonal trust relationships by looking at the attributes that can be enabled in working departments in hospitals that facilitate trust building and communication, and thus, enable effective knowledge sharing. This is an exciting environment to look at because physicians are an example of a group that needs to work cooperatively.

Methodology. McAllister [3] has developed an instrument based upon a review of trust literature and other interpersonal trust instruments. This questionnaire was translated into Chinese and administered to physicians in three sections of a Teaching Medical Center.

This population was selected because a teaching medical center represents a knowledge-intensive work environment, and knowledge transfer within a teaching medical hospital is essential for training new physicians. These physicians, in turn, go out to other hospitals to start their careers and help to create cultures where trust and knowledge sharing are important aspects of the work environment.

The study includes both qualitative and quantitative date. The qualitative data is based on interviews with section heads, who are charged with knowledge sharing within their section. The semi-structured interview and the open-end survey encouraged the respondents to share their views. In addition to the interviews, a quantitative survey was administered to physicians. Descriptive statistics were generated for the physicians' responses. These statistics were used to describe the type of work environment that must be created in order to encourage trust and facilitate knowledge transfer.

Findings. The interviews lead us to consider the teaching medical center to have a hybrid of a clinical culture and control-based model. A major characteristic of the clinical culture is the autonomy of physicians. This autonomy may be a barrier to carrying out quality improvement projects because physicians perceive quality improvement efforts as a disturbance in their professional practice.

Physicians seem to place more trust in those who have similarities to themselves. For example, they may share knowledge more freely with those who graduated from the same school or associate with a defined group, such as the local church. This highlights an important phenomena in health care -- the professional hierarchical relationships which may repress dissent and disagreement between residents (subordinates) and attending physicians (superiors), between nurses and doctors, and between patients and medical

staff. This hinders the mutual communication that is essential for detecting and correcting medical errors. Healthcare workers working as part of the teamwork often encounter identity group boundaries that, when compounded with status differences, influence communication and collaboration in the teamwork. One section head stated that sharing knowledge in a teaching medical center is quite unique because he knew some of his staff as medical students. This reinforces the hierarchical problems. On the other hand, such long-standing relationships served to reinforce the atmosphere of trust, as reported some of the section heads. The heads of the sections believed in the relationship between trust and tacit knowledge exchange. They saw relationship building as a key to success for sharing tacit knowledge. One section head said “No one is perfect, everyone has a blind side. It is always good to have someone watch my back for me.” One can only feel that comfortable if there is trust.

While formal communication avenues such as mandatory weekly meetings at which medical staff recap medical journals, do case demonstrations, and discuss research reports, are important, physicians indicate that conversational and straightforward communication fosters their decision to trust one another. Attributes like candor and practices like fair treatment are mentioned by physicians as things that help foster communication, and thus knowledge sharing.

Physicians who worked in departments where there is high trust used words like fun, supportive, motivating, productive, and comfortable when describing their work environment,. Physicians in departments where there are low levels of trust used words like stressful, threatening, divisive, unproductive, and tense when describing their departments.

Conclusion. The findings indicate that a hospital environment that facilitates communications and places a premium on relationship will do well in their knowledge sharing efforts. Physicians must demonstrate predictability and integrity. Physicians state that they often asks themselves "How positive am I of how the person I am about to trust will act?" A trustee whose behavior can be consistently predicted will be seen as more trustworthy, one whose behavior is unpredictable will be met with suspicion. When departments heads over promise but under deliver, problems arise.

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KEEPING PEOPLE INVOLVED: AN EXAMINATION OF RESOURCE VARIETY AND CONTRIBUTION MOTIVATION AS FACILITATORS OF MEMBER RETENTION IN USENET NEWSGROUPS

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ABSTRACT

Within the research domain into online communities, studies investigating the factors contributing to the sustainability of those online communities have been relatively sparse. This study is an empirical investigation of such factors in one of the largest online communities, USENET. As a measure of sustainability of online communities, *member retntion* is assessed using a returning member ratio. Facilitators that have positive impacts on member retention are derived from two measures, namely *resource variety of the online community* and *contribution motivation of the participants*. The relationships between member retention and the two facilitating factors are empirically examined using multiple regression models.

1. INTRODUCTION

Supported by today's computer and networking technology, people get involved in online community activities. The emergence of online communities has brought a profound impact on human interaction and methods of information exchange in today's society in terms of a new type of social structure in cyber space.

In order to be able to assess how successful a social structure is, it is imperative to consider the sustainability of the social structure since without this fundamental premise of its own existence, it is meaningless to talk about a successful social structure. For a social structure to be sustainable, members should be motivated to participate and remain in the community. Based on the utilitarian perspective Butler (2001) proposed resource based model and empirically investigated the model arguing that membership size reflects the resource variety availability and in turn indicates the benefit provision of an online community thereby establishing the sustainability of an online community. And thus, the core part of such resource variety is to facilitate it through member retention and attraction.

Wang and Fesenmaier (2003) contend that community members' contribution motivation is the basic component of the members' active contribution participation. Their empirical study showed that contribution motivation derived from the members' motivational sources (i.e. instrumental,

efficacy, and expectancy) has a positive impact on the members' active contribution to the community. Drawing from the implication from this study and reflecting it to Butler's resource based model of sustainability, it could be reasonably theorized that members' contribution motivation leads to their active actual contribution (e.g. knowledge, time, energy, etc); such contribution increases the available resource pool of the online community; and thus in turn would positively affect the member retention, making the community more sustainable.

Of the various types of online communities USENET newsgroup stands out in terms of its scale, diversity in format, and multi-faceted nature of social interaction. Usenet is one of the oldest computer network communications systems still in widespread use. Established in 1980, USENET is a worldwide teleconferencing system consisting of various types of newsgroups with names starting with several top level hierarchies (i.e. comp, rec, soc, sci, talk, alt, etc.). It is believed that there are currently well over 100,000 USENET newsgroups and thus, without a doubt, USENET is one of the prominent examples of online community phenomena that deserve research attentions.

In the context of USNET newsgroup, our study examines each of the influence of the resource variety factor from Butler's model and the contribution motivation factor from Wang and Fensenmaier's study with respect to the member retention, which is the facilitator of the sustainability of an online community. Our study further integrates these two factors into one model to see if the combined model better explains the relationship between the member retention and its facilitating factors suggested.

2. VARIABLES AND HYPOTHESES

2.1. Dependent Variable (DV): Member Retention

The membership size of an online community reflects the sustainability of the community (Hagel & Armstrong, 1997; Ridings & Gefen, 2004) in terms of the resource availability, and is an indicator of sustainability in the sense that it is reflective of the community's current level of benefit provision (Butler, 2001). In case of USENET newsgroup, however, the size of returning members is an indicator of the community's on-going attraction for members and reflective of the community's ability to retain the existing members. It is because, in this study, membership is defined by the fundamental interaction activities such as message posting and replying to the initiated messages. Hence it is a reasonable approach to consider the community's persistent propensity to retain members a lead to the community's sustainability. Based on this reasoning, we employ the size of returning members measured by the proportion of the number of returning members to the total membership size as the dependent variable in this study.

2.2. Independent Variables (IV's): Facilitators of Member Retention

2.2.1. *Resource Variety*

Inferred from the resource base model, the utilitarian perspective assumes that instrumental benefit at an individual level is the main motivational force towards the participation into the online community (Furlong, 1989; Ridings & Gefen, 2004). Members of USENET newsgroup

are initially information seekers who want to utilize the resource base available in the online community (i.e. a USENET newsgroup) by initiating their messages (posting messages) asking or requesting information of their interests. Their needs for information can be better served from the online community with more variety in its available resource base. If their utilitarian needs are better satisfied from a specific online community than others, it is highly likely that the member would return to the community in the future. Increased number of returning members contributes to the membership size of the community and in turn enhances variety of the community's available resource pool. This leads to our first hypothesis.

***H_1**: Resource variety has a positive impact on the member retention of an online community.*

2.2.2. *Contribution Motivation*

The underlying assumption in online communities is that the information provision to the unknown recipients usually involves an unstated obligation to repay the transaction at some time in the future (Wang & Fesenmaier, 2003). Stated simply, the motivation for the members of an online community to contribute by providing information needed assumes, 'I'll do this for you now, knowing that somewhere down the road you will do something for me' (Wang & Fesenmaier, 2003). Although it might be true in off-line community context, such assumption is more weakly tied to the motivation in off-line context. In case of off-line context, physical contact and more obvious identification of counterparts tend to make the motivation leaning more toward direct, immediate and tangible terms such as monetary compensation and/or saving of social status.

The propensity of this contribution motivation would enrich the resource base of the online community and such enriched resource base would serve the community members better with regard to their information needs fulfillment. If the members' needs are better satisfied from a specific online community than others, it is highly likely that the member would return to the community in the future. This leads to our second hypothesis.

***H_2:** Contribution motivation has a positive impact on the member retention of an online community.*

In each of the two previous hypotheses, we suggest the impact of resource variety and contribution motivation respectively on the member retention of online communities in the context of USENET newsgroup. By combining the two facilitators into one model we can examine the possible difference of impact between the facilitators. Hence, we propose the third hypothesis that combines the two facilitators (i.e. resource variety and contribution motivation) in regards to their impact on the member retention as below:

***H_3**: When considered simultaneously, resource variety and contribution motivation have a positive impact on the member retention of an online community.*

3. METHODOLOGY

3.1. Data Collection

The current study used secondary data sourced from a publicly available Web service site, Netscan (located at http://netscan.research.microsoft.com/). This site provides a global view of the social accounting metrics (meta-data) that measure social dimensions of online communities such as the size of newsgroups in terms of the number of messages and number of participants (Brush, Wang, Turner, & Smith, 2005; Smith, 2002). From the Netscan site monthly data for the nine fundamental metrics provided were compiled for each of the newsgroups under each of the five top-level hierarchies (e.g. all newsgroups starting with 'comp'). A data set for one year period (Jan. 2004-Jan. 2005) was collected combining two consecutive months as one period of temporal pair. A total of 45,360 data points were compiled for the twelve pairs of period.

3.2. Operationalization

Member Retention *(DV):* Given posting and replying by text based messages as the fundamental interaction activities of USENET newsgroups, membership can be defined by the action of doing either of such activities. Hence, the member retention is measured by the proportion of the number of returnees[1] to the total number of posters in the previous period for the group (See Table1. for detailed formulation).

Resource Variety *(IV):* Resource variety is measured by the number of initiated messages per poster. Basically the number of messages represents the available resource base of the online community. In this study, however, we separate the initiated − i.e. asking questions or suggesting topics − messages from replies since, the initiated posts are more related to the resource variety whereas the reply portion is related to the motivation to participate. Hence, in this study, we define the resource variety as the number of such initiated messages standardized per poster (See Table1. for detailed formulation).

Contribution Motivation *(IV):* Contribution motivation represents the extent to which the members of the online community are willing and actually take action of providing information to the information seeking other members of the community without any immediate reward for such contribution. It is hence measured by the number of replies to the initiated posts per replier (See Table1. for detailed formulation).

The values of all variables are calculated using the dataset obtained from Microsoft Netscan website. Then, log10 transformations were applied to the calculated variables to avoid possible non-normality problems in multiple regression analyses. In taking the log transformation, a constant value (1.00) was added to the ratio so that the cases of zero (0) numerator are not excluded in the assessments.

[1] The authors who posted or replied at least one message to the newsgroup in the time period selected that also posted or replied in the previous time period.

4. Empirical Results

Descriptive statistics for the three regression models (i.e. Model 1, 2, and 3) carried out are presented in Table1. Statistical tests are conducted based on a 0.1% level of confidence. The correlations among the variables are examined and there found no indication of multicollinearity.

Table1. Descriptive Statistics (Log-transformed)

	N	Min	Max	Mean	SE	Formulation
Retention (*Y*)	45,360	0.000	0.301	0.056	0.0003	Log10(1+(Returnees/Posters))
Variety (X_1)	44,997	0.301	3.524	0.434	0.0009	Log10(1+(Posts-Replies)/(Posters-Repliers))
Motivation (X_2)	26,617	0.301	2.805	0.560	0.0016	Log10(1+(Replies/Repliers))

The regression results for all three models are presented in Table2. In model (1), the result shows the regression model is significant and in model 2, the result finds that the regression model is also significant. Model (2) has more explanatory power than model (1) with respect to the variation in member retention.

Table2. Regression Results

Variable \ Model	(1)	(2)	(3)
Resource Variety (X_1)	.595 ***		.245 ***
	(.001)		(.002)
Contribution Motivation (X_2)		.662 ***	.500 ***
		(.001)	(.001)
***Adj.* R^2**	0.353	0.438	0.483

Dependent Variable: Member-Retention (***Y***)
Standard Errors (SE) are in parentheses, *** denotes p <.001

In model (3), multiple regression results reveal that the model is significant, $F(2, 26251) = 12240.61$, $p < .001$, *Adjusted* $R^2 = .483$. The results also show that all the independent variables (i.e. resource variety and contribution motivation) are significant; Variety ($t = 39.21$, $p < .001$); and Motivation ($t = 79.99$, $p < .001$). Referring to the standardized estimates (Beta-weights), Motivation (*Beta* = .500) is found to be the most contributing one between the two antecedents to the member retention compared to the other antecedent, Variety (*Beta* = .245). Considering the significant simple regressions for each of the independent variables and the significant positive coefficients in the multiple regression model, all three hypotheses for the antecedents of member retention are.

5. Discussion

The current study intended to examine the relationship between the member retention and its facilitators namely, resource variety and contribution motivation based on resource based model of sustainability (Butler, 2001) and literatures on the motivations to participate in online community interaction activities. Drawing upon these previous studies, the current study

hypothesized on the relations among member retention (as dependent variable), resource variety, and contribution motivation. Variables are defined and operationalized and sample data are compiled from a publicly available Web site, (http://netscan.research.microsoft.com). In order to test these hypotheses, we incorporated a set of regression analyses as the statistical models.

The regression analysis results show: 1) a positive impact of resource variety on member retention of an online community; 2) a positive impact of contribution motivation on member retention of an online community; 3) positive effects of resource variety and contribution motivation on member retention of an online community when considered simultaneously in one combined model with a better explanatory power; and 4) Between the two facilitators, contribution motivation appears to have greater impact on the member retention than the resource variety.

The findings of this study might be used as a platform model in designing an online community network with regard to what to consider and where to focus on in order to make the online community network working and sustainable. For instance, decision makers and practitioners of online community establishments could use the model suggested in this study as a reference framework for designing the online community network structures, features, strategies and policies in regard to the online community's resource variety and contribution motivation. In terms of academic contribution, the current study explored the facilitators of online community member retention by empirically investigating the online community activities in one of the most popular type of online community, the USENET, thereby enhancing the understandings of the sustainability and its facilitating factors of an online community. Furthermore, the current study probed into and empirically examined the effects of the two facilitators of member retention in one model that better explains the phenomenon in the context of online community interactions.

Although the findings of the current study made a modest contribution in both practical and academic respect, however, there are limitations and thus several related venues of further research could be undertaken. First, although the current study investigated the sustainability of an online community in terms of its member retention, it would be better to follow up the actual duration of the online community so that the suggested model of sustainability can be verified directly from the longevity of the online communities in relation to the factors that affect the longevity. Hence, it would be a promising future research theme to investigate longitudinally the duration of online communities in relation to the resource variety and the members' contribution motivation of the online communities. It might be also possible to examine the other sustainability (dependent) and/or the facilitating (independent) measures other than the ones employed in this study. The metrics such as frequency of the community activity or the extent of members' activeness (e.g. the ratio between the lurkers and posters) can be developed in the future studies either for the dependent or the independent factors such that the models using those factors as variables can explore another dimension of the online community dynamics separate from the model examined in the current study.

(References available upon request from *Kyung Woo Kang University of Rhode Island)*

Paper P061012027:

"A Preliminary Assessment of the Validity fo a Computer Literacy Construct: Conceptualizing and Operationalizing on Numerousness"

is not included here because it is a protected file.

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AN INVESTIGATION OF THE USE OF FUZZY RULE-BASED SYSTEMS TO INTERPRET ORGANIZATIONAL BEHAVIOR RESEARCH SURVEYS

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ABSTRACT

Research into organizational behavior often utilizes extensive surveys as tools for measurement of participates' attitudes, perceptions, and behavior. Interpreting the results of these surveys, in any sense, can be a challenge. Quantifying those results in order to enable any form of statistical analysis or hypothesis testing is even more difficult. In this paper we will look at the potential of an evolving expert system tool, fuzzy rule-based systems, for interpreting and quantifying the results of surveys. The impetus for this investigation is an ongoing study that attempts to identify factors that contribute to dysfunctional budget behavior in public accounting firms.

INTRODUCTION

Assessments of individual and organizational behavior cannot be performed in ways analogous to assessing financial or production performance. Precise measurements such as budget deficits, rates of return, or costs per item cannot easily be collected when studying behavior. However, researchers who wish to evaluate hypotheses about organizational behavior need some forms of measurement in order to perform traditional statistical analysis. A readily available solution is the use of extensive surveys to collect "data" from both individuals and organizations.

Evaluating the results of these surveys can be very difficult, particularly if the process is to be defendable and repeatable. The difficulties come from several perspectives. The information contained in the surveys is by definition imprecise. They almost always contain opinions. One responder will certainly interpret questions differently from another. Processing and interpreting the survey results creates even more imprecision. Not only might two responders interpret the same question differently, but two survey evaluators are likely to interpret the same answer differently. Invariably some effort is made to produce quantitative measures that hopefully will be consistent as well as understandable and hence believable. There are a few quantitative tools available. Simple averages and standard deviations can be calculated for individual survey questions if the answer is quantitative or multiple choice. Coefficients of correlation and regression can be used to assess relationships. But these traditional attempts to quantify survey results can end up actually exaggerating the imprecision in the data by attempting to make precise a process that is inherently imprecise.

In addition to inherent imprecision, most means of quantifying survey results do not allow the results from one survey question to be used to score the results of another. For example, client satisfaction surveys often ask questions about the quality of the work performed, the timeliness of the work, and in some cases, the importance of the work. The score for a particular work

performance might well be the sum of the scores in the three categories. However, a very important task performed only satisfactorily should produce a lower score than a less important task performed at the same level. In short, an effective evaluation requires the ability to make judgments in context.

Fuzzy rule-based systems (FRBS), a recently introduced form of expert systems, have the potential to contribute to researchers' ability to analyze surveys. FRBS combine fuzzy set theory with knowledge based expert systems. Fuzzy sets allow one to express imprecision by indicating the degree to which a conclusion is true, in contrast to limiting the conclusion to a dichotomous true or false. Fuzzy set theory has been used in the past fifteen years in numerous scientific and engineering applications, primarily in control systems and pattern recognition [1]. Rule or knowledge based expert systems have also been in popular use in the same time frame [2]. One team of the authors has developed a system that refines the utilization of these two analytical tools in a manner that produces an efficient methodology for evaluating complex organizations. FRBS have been recently used to evaluate the government of the fifty US states [3], the financial health of the thirty-five largest US cities [4], [5], [6], the financial condition of over 600 school districts in New York State [7], and the credit worthiness of 25 US publicly owned airports [8]. In this paper we investigate the adaptability of FRBS to scoring survey results.

The impetus for this evaluation is an ongoing effort to identify the factors that contribute to dysfunctional budget behavior in public accounting firms [9]. One of the surveys utilized in this behavior study is evaluated using FRBS and the results compared to the straight forward results produced in the initial study. A look at specific results suggests that FRBS provide a much more robust measure of the variables utilized in the research investigation.

The first section of the paper briefly describes the behavioral research investigation and the survey instruments. The second section introduces fuzzy rule-based systems in the context of evaluating one of the surveys. The third section includes the results of the fuzzy evaluation along with a comparison to the more traditional results. The final section looks to the development of a strategy for the ongoing behavioral investigation based on an even more sophisticated use of FRBS.

FACTORS RELATED TO DYSFUNCTIONAL BUDGET BEHAVIOR

Behavioral studies of the budget process have sought to identify factors, which inhibit or enhance budget performance within an organization. Organization behavior theory suggests that the more involved individuals are in the organization's decision making process, the greater is their commitment to achieving organizational goals, and hence the better the performance of both individuals and the organization [10], [11],[12]. The purpose of this behavioral research is to empirically investigate the relationship between an individual's locus of control, perceived degree of budget participation, perceptions of the organization's reward structure and the individual's perceptions of the tendency of others to engage in dysfunctional budget behavior from a foundation provided by a cognitive psychological theory. Accounting research identifying and

examining the relationship between these exogenous variables and dysfunctional budget behavior is almost nonexistent.

In order to gather the data necessary for the aforementioned study, a questionnaire was designed including measurements for each of the relevant variables. This paper focuses on the survey questions designed to measure perceptions of the organization's reward structure. The reward structure questions are based on an instrument originally constructed and tested by Porter [13]. It contains sixteen questions classified into several need categories such as security needs or esteem needs. Respondent attitudes towards these need categories were used to construct a measure of the salience of intrinsic and extrinsic rewards associated with their respective positions. Each question addresses the level of reward that currently exists, the level that should exist and the importance to the respondent. All three levels are measured on a scale from 1 to 7 with 1 identified as the minimum amount and 7 the maximum amount, but with no further delineation. Individual questions were scored by looking at the difference between the level that should exist and the level that currently exists. This scoring system however does not distinguish between a number of responses that might suggest very different attitudes towards the institutional reward structures.

Consider responses to the questionnaire item addressing "the authority connected to my current position". A respondent recording a 3 for "how much there is", a 4 for "how much there should be" and a 7 for "how important this is to me" would get a score of 1 ("should be" minus "is"). Another respondent recording a 6 for "is", 7 for "should be", and 4 for "importance" would get an identical score. However the perception of the rewards structure is very different for the two people. The development of expert systems suggests that an "expert" could assign an appropriate rule to score every possible combination of responses to the three parts of the question. In this case that that would require 343 (7 x 7 x 7) rules for each item in the questionnaire. This exponential growth in the required number of rules has limited the usefulness of rule-based expert systems for complex situations. Fuzzy set theory in fact enables us to address this concern.

USING FUZZY RULE-BASED SYSTEMS

One of the many benefits of fuzzy rule-based systems is that they can handle complex systems with relatively few rules. Considering again the example of "perception of authority", we can define the levels for our survey responses using only three categories rather than seven, requiring a total of only 27 (3 x 3 x 3) rules. For the response to "how much is there now" we will identify the levels as low, moderate, and high. For the response to "how much should there be" we will look at the difference between "should be" and "is" and classify that difference as negative, neutral, and positive. Similarly for importance we will consider the difference between "importance" and "is" and classify the difference also as negative, neutral, and positive. With these definitions we can create rules such as:

> If "How much there is now" is MODERATE
> And "should be" minus "is" is POSITIVE
> And "importance" minus "is" is POSITIVE
> Then the perception of authority connected to the job is LOW.

This rule would describe a respondent who, although his or her level of authority is moderate, believes that it should be higher and believes that it is important. Similar rules can be defined for the other 26 possible combinations. The selected results for all 27 rules are described in the rule matrix shown in Figure 1. The shaded cell corresponds to the sample rule described above.

Authority: "how much is there now?"

should be - is	low			moderate			high		
	importance - is			**importance - is**			**importance - is**		
	neg	neutral	pos	neg	neutral	pos	neg	neutral	pos
neg	mod	mod	low	high	high	mod	mod	mod	low
neutral	mod	mod	low	high	high	mod	high	high	high
pos	low	low	low	mod	mod	low	high	high	mod

FIGURE 1. Authority Rule Matrix

If we are going to classify the responses to the questionnaire with three categories, we need to assign the numerical scores from 1 to 7 to each category. Table 1 summarizes a possible way to do this.

	low	moderate	high
How much is there now	1,2	3,4,5	6,7
	negative	neutral	positive
"should be" minus "is"	< -1	-1,0,1	>1
"importance" minus "is"	< -1	-1,0,1	>1

TABLE 1. Classification of numerical responses.

Using these 27 rules in a traditional manner can result in unsatisfactory outcomes. Consider for example three respondents with slightly different responses as summarized in Table 2. First compare respondent #1 and #2. A one unit change in "how much there should be" and in "how important is this to me" produces no change in the result because the changes were not sufficient to change categories. However comparing Respondent #2 to #3, a one unit change in both categories abruptly changes the rule conclusion from high to low! Changing how the questionnaire scores are assigned to the three categories will not alleviate the problem. There will always be a situation in which an increase of one results in an abrupt change in categories and hence an abrupt change in rule conclusion.

Respondent	How much is there now	How much should there be	How important is this to me	Rule Conclusion
1	3	3	3	high
2	3	4	4	high
3	3	5	5	low

TABLE 2. Three hypothetical responses to authority question.

Fuzzy set theory allows us to avoid such abrupt changes by eliminating the instantaneous jump from one category (set) to another. A fuzzy set is defined by a membership function that ranges between 0 and 1, which assigns the degree of membership to each element in the set. Intuitively, the degree of membership represents the extent to which an element can be placed in the set. Under fuzzy set theory, an element can belong to more than one set with different degrees of membership. For example, a score of +1 for "should be" minus "is" can be a member of both the neutral set with membership level of 0.67 and at the same time a member of the positive set with a membership level of 0.33. This would indicate that on a continuum between neutral and positive, this response would be closer to neutral.

Developing fuzzy sets involves constructing sets for each ordinal category, which captures the range of values associated with this category. For example, we might decide that the set for negative would be all negative values, the set for neutral would cover the range from -1 to 1, and the set for positive would be all positive values. Any score above 3 would be considered fully positive with a membership in this set of 1, and membership of 0 in the other two sets. Likewise, any score below -3 would be considered fully negative with a membership of 1 in this set, and membership of 0 in the other two sets.

Looking at the boundaries of each set, it is clear that they overlap. This is where the concept of a fuzzy set comes from, since one score can be a member of more than one set. The final step in this process is to assign membership levels between 0 and 1 in each set to each score. A membership function can take a number of different shapes, but triangular functions are very common, because they imply a smooth transition between sets. Referring to Figure 2, the membership functions for negative, neutral, and positive are illustrated. A score of 1 for "should be" minus "is" on the authority question would be a member of both the neutral and positive category. To find the membership levels draw a vertical line above 1 (on the X axis), and find the points of intersection with the positive (0.33) and neutral (0.67) categories. The gradual transition is identified by the membership function. A slightly higher score will still be a member of the two categories, but less in the neutral and more in the positive. With a high enough score (above 3), a response will cease to have membership in the neutral category.

Since any particular questionnaire score can hold membership in more than one set, more than one rule will be used to evaluate the survey response. Consider our respondent # 2 from Table 2. Table 3 contains the fuzzy membership levels for each trait. The fuzzy membership functions are determined as illustrated in Figure 2. Different membership functions are defined for each of the three traits.

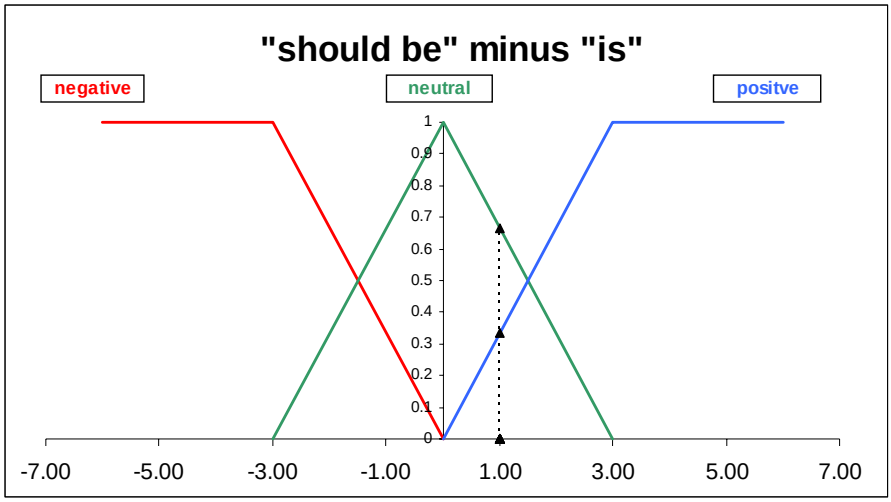

FIGURE 2. Fuzzy Membership Functions for Questionnaire Scores.

traits	low	moderate	high
How much is there now?	0.20	0.80	0
	negative	neutral	positive
"should be" minus "is"	0	0.67	.033
"importance" minus "is"	0	0.80	0.20

TABLE 3. Fuzzy membership levels

The fuzzy membership functions actually result in the application of eight different rules as show in Figure 3. Since the respondent's scores have membership levels to varying degree, the rule conclusions will also hold to varying degrees.

Authority: "how much is there now?"

should be - is	low			moderate			high		
	importance - is			**importance - is**			**importance - is**		
	neg	neutral	pos	neg	neutral	pos	neg	neutral	pos
neg	mod	mod	low	high	high	mod	mod	mod	low
neutral	mod	**mod**	**low**	high	**high**	**mod**	high	high	high
pos	low	**low**	**low**	mod	**mod**	**low**	high	high	mod

FIGURE 3. Rule Matrix for Respondent # 2

Only one rule results in a conclusion that the perception of authority associated with the respondent's current position is high. This rule is summarized in Figure 4. The membership in

the high conclusion is defined to be the minimum of the memberships for the relevant rule traits since the rule only holds to the extent to which it is true for all three traits.

High Rule			membership
IF	"how much is there now"	is moderate	0.80
AND	"should be" - "is"	is neutral	0.67
AND	"importance" - "is"	is neutral	0.80
THAN	perception of authority	is high	0.67

FIGURE 4. High Rule for Respondent #2

Three rules result in the conclusion that the perception of authority is moderate. All three are summarized in Figure 5. With three moderate rules we have a fuzzy measure of moderate at three levels (0.20, 0.20, and 0.33). Since all are descriptions of a moderate conclusion we can assign the overall moderate conclusion to be the maximum of these three. Hence we conclude that the respondent #2's perception of authority for the current position is moderate with a fuzzy membership of 0.33. We have already concluded that the perception of authority is also high with a fuzzy membership of 0.80. A similar application of the four "low" rules adds the conclusion that the respondent #2's perception of authority is also low with a fuzzy measure of 0.20.

Moderate Rule #1			fuzzy membership
IF	"how much is there now"	is low	0.20
AND	"should be" - "is"	is neutral	0.67
AND	"importance" - "is"	is neutral	0.80
THAN	perception of authority	is moderate	0.20

Moderate Rule #2			fuzzy membership
IF	"how much is there now"	is moderate	0.80
AND	"should be" - "is"	is neutral	0.67
AND	"importance" - "is"	is positive	0.20
THAN	perception of authority	is moderate	0.20

Moderate Rule #3			fuzzy membership
IF	"how much is there now"	is moderate	0.80
AND	"should be" - "is"	is positive	0.33
AND	"importance" - "is"	is neutral	0.80
THAN	perception of authority	is moderate	0.33

FIGURE 5. Moderate rules for respondent #2.

Hence for respondent # 2 we have fuzzy rule conclusions that state the level to which the respondent's perception of authority in his or her current position is low, moderate, and high. The results can be defuzzified (using a center of gravity calculation) to produce a single value on

any scale. It is the fact that multiple rules (eight in this case) are used to interpret each situation that allows FRBS to handle complex situations with a relatively few number of rules.

Repeating these calculations for the three hypothetical respondents compared in Table 2 produces results, as summarized in Table 4. Our initial crisp (not fuzzy) rules did not distinguish between the first two respondents, rating both as high. The defuzzified value (using a scale from 0 to 20) from the fuzzy rules appropriately rates the perception of authority higher for respondent #1. Similarly the difference between respondent # 2 and #3 is a more reasonable change rather than a jump from the highest to the lowest conclusion.

Respondent	Crisp Rule Conclusion	Fuzzy Rule Conclusions low	moderate	high	Defuzzified Result
1	high	0.00	0.20	0.80	17.6
2	high	0.20	0.33	0.67	13.5
3	low	0.40	0.60	0.33	9.5

TABLE 4. Comparison of results for three respondents.

FUZZY RULE-BASED SYSTEM RESULTS

The questionnaire used to evaluate individuals' perceptions of an organization's reward structure was given to twenty-five accountants at a public accounting firm. The part of the questionnaire relating to reward structure contained 16 questions with each question containing 3 parts, relating to the current status, the level it should be, and the importance to the individual. The original study [9] scored each question by subtracting the should be level form the current level ("should be" minus "is"). A FRBS was created to perform a comparable evaluation for each respondent and each question. As described above, fuzzy membership functions are defined for the three traits: current status, "should be" minis "is", and "importance" minus "is". For each question, the twenty-seven rule matrix is created. Definition of the membership functions and the rules for the matrix assume an expertise about the relationships between the traits. This expertise can be intuitive (as seems appropriate is this exercise) or it can have a basis in behavior or cognitive theory. In any case, a user can modify the rules and membership functions and observe and make conclusions about the preferred results.

A fuzzy rule-based system was developed for each of the sixteen questions and each was administered for all twenty-five respondents. In each case the fuzzy results were compared to the "should be" minus "is" calculation originally used in the study. In all cases the FRBS produced more robust results with greater delineation between different responses. For example, Figure 6 contains a graphical comparison of the fuzzy results to the original calculation for the question relating to the respondent's perception of the authority connected to his or her current position. For the twenty-five respondents the differences between the level of authority connected with the current position and the level that should exist all fall between 0 and 3. However some of the respondents with identical "should be" minus "is" scores present very different perceptions of the authority connected with their position and perhaps very different attitudes to perceiving dysfunctional behavior in others.

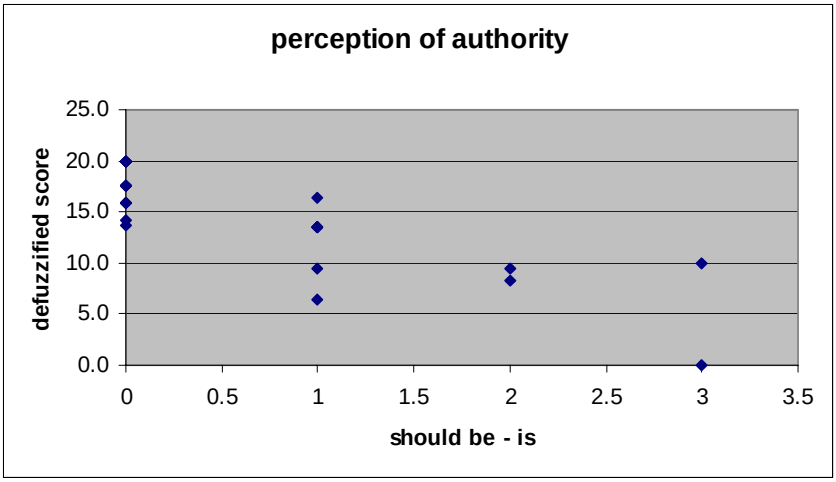

FIGURE 6. Comparison of fuzzy results with original research calculations.

Consider for example the results for four respondents summarized in Table 5. Respondent # 14 and #16 both believed that their level of authority is what it should be. However a respondent who believes his or her level of authority is appropriately low and could evidently care less is likely to have a very different attitude than someone at a high level of authority. Similarly respondent # 8's belief that his or her authority is minimal, should be much higher, and that it matters a lot, is a very different person from respondent # 5 who believes his or her authority should be much higher than the current moderate level but is little concerned about that difference.

Respondent	How much is there now?	How much should there be?	How important is this?	"should be" minus "is	Defuzzifed score
#16	2	2	2	0	13.6
# 14	6	6	6	0	20.0
# 8	1	4	5	3	0.0
# 5	4	7	2	3	10.0

TABLE 5. Comparison of four different respondents.

CONCLUSIONS

The results from the fuzzy rule-based system clearly provide a more robust interpretation of the survey results and arguably allow researchers more options for interpreting survey data. Certainly the selection of the rules and definitions of the fuzzy sets influences the results. The existence of expertise is an assumption in the use of "expert" systems. That expertise could come from the study of appropriate theory or it could come from experience. However, a fuzzy rule-based system, with its relatively few number of rules, actually allows a user to learn from the data. The researcher has the opportunity to think about relationships between different parts of a questionnaire and to seek a set of rules that provides insights into the data.

FRBS provide opportunities beyond interpreting single or small groups of questions on a survey. They also allow the option of comparing the relationships within the entire survey. Fuzzy rule-based systems require fuzzy inputs (as defined by membership functions) but they also produce fuzzy outputs (prior to defuzzification). When used to evaluate complex systems, the fuzzy output of one rule-base becomes input to a higher level rule-base. This approach could be applied in this context as well. The next step in investigating the use of FRBS for the dysfunctional budget behavior research will be to use higher level FRBS to evaluate the contextual relationships between the various measures of reward structure. Moving up one level higher, FRBS could potentially be used to evaluate the relationships between the three independent variables: locus of control, organizational rewards, and level of budget participation and the dependent variable, the perception of dysfunctional budget behavior in others. The use of FRBS ought to also provide a vehicle for more directly applying cognitive theory to this investigation. Leave two blank lines before major headings. Leave one blank line after major headings.

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WOMEN PENETRATING THE GLASS CEILING

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ABSTRACT

Based on general acceptance, the term *glass ceiling* refers to the condition in which top-level management in businesses, especially corporations, is dominated by a demographic referred to as white heterosexual men. This paper focuses on key management statistics from a research project and the possible impact of those management changes in the workplace of 2006 relating to the *glass ceiling*. An attempt is made to answer the question as to what progress women have actually made in penetrating the *Glass Ceiling* over the last decade.

INTRODUCTION

The term glass ceiling most commonly refers to the condition in which top-level management in businesses, especially corporations, is dominated by a demographic referred to as white heterosexual men. A "ceiling" is suggested because women are seen as limited in how far they can advance up organizational ranks. The ceiling is "glass" (transparent) because limitation is not immediately apparent. The glass ceiling is distinguished from formal barriers to advancement, such as education or experience. While the term is often used to refer to women's access to upper management, it also refers to the general tendency for women to be underrepresented at higher levels of the occupational hierarchy.

Think of a corporation, for example, as a pyramid. At the top is the Chairman of the Board and the President. As one goes lower on the pyramid one finds the Executive Vice Presidents, Senior Vice Presidents, Vice Presidents, Managers, Directors, Supervisors, and eventually one gets to the large number of workers who do the day-to-day work. Next, let us suppose that this corporation has one thousand workers who are comprised of fifty percent female, ten percent African American, twenty percent Latino, etc. In looking at the numbers, the corporation can claim that they do not discriminate against any protected group.

Now, let us see where these workers are located in the pyramid. Let us assume to draw a horizontal line in the pyramid at the Manager's level, approximately two-thirds up the pyramid. Above that line are the Managers and executives of the corporation. When we look at that imaginary line, we find that 100 percent of the people from managerial positions to chairman of the Board are white, Anglo-Saxon males. The imaginary line is the glass ceiling, below which is found the group of females, the African-Americans, the Latinos, etc. and above which the females, African-Americans, Latinos, etc, cannot rise. That imaginary line may apply to all or any of a protected group. Glass ceiling cases are primarily proven by statistics.

PENETRATING THE GLASS CEILING

The objective of the research used as the basis for this paper is to focus on some of the progress women have made in the workplace as managers in business firms over the last fifty years. A career is important because it represents a person's work life setting and affects their quality of life. For women, having a career means being able to express their professional selves over their lifetime with a desire for just treatment and compensation for their efforts [10].

When I entered the workforce during the 1950s, less than 35 percent of the American women worked outside the home, according to the U. S. Bureau of Labor Statistics. Those of us who did, came under much criticism if we were also mothers. By 2004, the thinking had changed, although it appears to make a bigger positive difference if the children are grown. One unidentified leader asserted that one of the best training grounds for leadership is motherhood; because if you can manage a group of small children, you can also manage a group of bureaucrats. It is almost the same process [12]. Today, more than 70 percent of women with children are either working full-time, part-time, or looking for work. But University of Maryland sociologist, Suzanne Bianchi, is careful to caution those who use that statistic to be mindful that only about a third work full-time, year-'round; many are working part time or only part of the year [7]. No matter, because women, both with and without children, are still very much a part of today's workforce. They are said to possess skills learned close to home: a collaborative style, community building with a focus on broader issues, better listening skills than men, and a tendency to reach across lines of authority [4, 12].

The number of women in the workplace increased by a mere 5 percent during the 1960s. But, that number steadily increased and zoomed to more than 50 percent during the 1980s. During the 1990's, the number of working families with stay-at-home fathers and working mothers rose by 70 percent [12]. Women's careers gradually began to be perceived in a more serious vein. It is not too surprising that during this time, women also began to pursue career-oriented studies (education) at institutions of higher learning in greater numbers than their male counterparts, according to the National Center for Educational Statistics. The literature holds much evidence that women are now having an easier and faster start on their career than they did in the past [4, 5, 6, 8].

In 2004, women comprised 51 percent of the U. S. population and 47 percent of the labor force, mostly on the lower rungs. By this time, women were earning 77 percent as much as men doing similar work on an annual basis and an all time high of 80 percent on a weekly basis [1]. It must be kept in mind that even though women are employed outside the home, they continue to be responsible for child care and managing the home in 90 percent of all marriages, according to research findings. These additional responsibilities present even more challenges for the female worker, especially at the low end of the earning scale where it is not feasible for the mother to hire outside domestic help. In many cases, this helps to explain why there are so many female workers who are not inclined to even compete for jobs that would allow them an opportunity to progress to the point of penetrating the 'glass ceiling'. For instance, approximately 62 percent of all workers who made the minimum wage in 2004 were women; so they were considered to be at the low end of wage earners where few, if any, glass ceiling penetrating opportunities were presented.

In 2005, 103.6 million Americans were full-time wage and salary workers; of these, 56.4 percent were men and 43.6 percent were women. Even though more women than men were working, women made up only 31 percent of the workers in the highest category (the top fourth quartile of workers by earnings). They made up a slight majority of the lowest earnings category (the bottom fourth or first quartile) which equates to 53.2 percent, compared with 46.9 percent for men.

HR professionals are well aware that a true gender-based pay gap exists only if a man and a woman are paid differently while having the same responsibilities and experience – unequal pay for equal work. The HR professionals in the HRfocus survey, reasoned that existing gender-based pay gaps in their organizations were frequently unintentional on a conscious level. But they did not dispute the fact that statistics show that females, on average, earn less than men. Findings from another study suggested that male employees have more of a tendency to negotiate for a higher starting salary, thus the explanation for the wage disparity.

When we examined the differences among lowest and highest earning workers in industry, we noticed that more than a third of women, but 10 percent of men worked in education and health services. About 10 percent of the men worked in construction, compared with 1.5 percent of women. Women and men in the lowest earnings category were twice as likely to work in leisure and hospitality and somewhat more likely to work in wholesale and retail trade than were women and men overall. In spite of these similarities, differences surfaced in where women and men in the lowest categories worked. Education and health services had the largest portion of women with the lowest earnings (29%), while manufacturing and construction combined for that portion of men with lowest earnings.

Education and health services also attracted the greatest proportion of women with the highest earnings (40.4%), so they accounted for large concentrations of both highest and lowest earning women. Professional and business services along with financial activities accounted for nearly the same share of highest earning women, as well as for a relatively large share of men with the highest earnings. Construction and manufacturing reflected more than 1 in 4 highest earning men, compared with 1 in 10 women. Overall, more women than men were in the lowest earnings category. The highest earners in the 2005 statistics from the U.S. Bureau of Labor Statistics were concentrated in industries including financial activities and professional and business services [3].

We are making tremendous strides by most accounts. In 2005, women accounted for half the managerial jobs and half of the law-school graduates [7]. Yet, we have not come close to reaching parity with our male counterparts. The problem is that getting women into corporations in not the same as moving them up. Indeed, we have female representation in the Fortune 500 company boardrooms, as well as in the Senate of the United States, but women still face lots of resistance and all are not reaching their career goals.

In 2005, Mary Minnick and Mary Dillon took over the top spot of Chief Marketing Officer at Coca-Cola and McDonald's respectively. Mary Lynn Ferguson-McHugh has worked her way up the Proctor & Gamble's brand management ladder and now holds the post of vice president of North America family care, a division that includes the Charmin, Bounty and Puffs brands. Earlier this year, PepsiCo's Indra Nooyi became just the 11th woman, ever, to preside as chief executive over a Fortune 500 company. Nancy Pelosi of California is leading the Democrats in the House of Representatives. Other female chief executives can be found in top spots at Coca-Cola, McDonalds, General Electric, Hewlett-Packard, Staples, Yahoo, AT&T and Visa [4]. Then, there are super-achiever women like Oprah Winfrey, Condoleezza Rice, and Hillary Clinton. These women are all exceptional examples of those who have actually penetrated that

double-paned glass ceiling. Once the ceiling has been penetrated at a given company, it tends to pave the way for other females who aspire to follow in their success.

In 2005, women's median usual weekly earnings rose to 81 percent of men's among full-time wage salary workers [1, 2]. While this proportion has continued to rise over the past decades, women are still underrepresented among the highest earners and overrepresented among the lowest workers, according to the 2005 Current Population Survey [1, 2]. In her research findings, Marie Wilson [12] found that women who were among the top wage earners at their companies make 68 percent of the compensation of men doing the same job. Even in the world of non-profits where women are thought to be doing well, an enormous pay gap still exists. Women at the top, on average, earn nearly $100,000 less than their male counterparts: $170,180 compared to men's $264,602. It can clearly be seen that we have made an enormous amount of progress, but we still have a long, long way to go.

What are some of the reasons for success? In the findings from studies performed by Rose Mary Wentling [11], the six major factors identified by women managers in her study regarding penetrating the glass ceiling include: 1) demonstrating competency on the job (resulting in high quality work); 2) good interpersonal skills; 3) perseverance or persistence; 4) being given the opportunity and support by the company; 5) a willingness to take on new things and new responsibilities; and 6) hard work. The personal sacrifices the study participants had to make in order to continue to advance toward the position they aspired to include: 1) time with family; 2) personal/free time; 3) social time/friendships; 4) relocating; 5) under too much stress/pressure; and 6) working too many hours at home. What kind of barriers prevent the advancement of qualified minorities and women? The six major barriers include: 1) being a woman; 2) lack of opportunity; 3) family obligations; 4) lack of support from her boss; 5) down sizing or reorganization impacts; and 6) lack of appropriate training [11].

The Federal Glass Ceiling Commission was established by Title II of the Civil Rights Act of 1991 to determine the barriers, also. The Commission was a 21-member bipartisan commission appointed by President Bush and congressional leaders with a legislative mandate to: conduct a study identifying the barriers that prevent, and the policies and programs that promote minorities and women upward in corporate America; present an annual Presidential award to a business who has made significant efforts to remove obstacles to career growth and has provided advancement opportunities to women and minorities; and educate the public on who is effected by and what can be done to remove glass ceiling barriers. The Commission completed its legislative mandate in November 1995 under the leadership of Robert Reich, Secretary of Labor, and was terminated by law Redwood, 1991 [9]. The Commission identified three groups of barriers.

They are: 1) Societal barriers, which include a supply barrier related to educational opportunities and the level of job attainment. There is also a "difference" barrier manifested through conscious and unconscious stereotyping and bias. It translates into a syndrome that people who do the hiring feel most comfortable "hiring people who look like them." Stereotypes must be confronted with hard data because, if left un-refuted, they become factual in the popular mind and reinforce glass ceiling barriers.

2) Governmental barriers include the collection and disaggregation of employment related data which make it difficult to ascertain the status of various groups at the managerial level. Also,

there continues to be inadequate reporting and dissemination of information relevant to glass ceiling issues. Most important, there needs to be vigorous and consistent monitoring and enforcement of laws and policies already on the books.
3) Internal structural barriers or business barriers include outreach and recruitment practices that do not reach or recruit women and minorities; Corporate climates that alienate and isolate; Pipeline barriers that restrict career growth because of poor training, inadequate mentoring, biased rating and testing systems; Few or no internal communication networks; Limited rotational job assignments that lead to the executive suite; and Institutional rigidity that deny the fragile family and work balance. Without access to mentoring, developmental assignments, training, and other career enhancing activities in the managerial pipeline, too many qualified people are stopped short, before they fulfill the promise of their abilities.

Other reasons for explaining why professional women's earnings are still different from men's are 1) motherhood - after having children, a professional woman may decide to become a teacher so she can have summers off – so her pay declines, 2) interruptions - when a women decides to take advantage of parental leave or maternity leave, she takes leave that tends to scale her back and keep her from advancing at the same rate of her male counterpart; interruptions in women's careers, for whatever other reason, tend to slow her progression, and 3) age – because women are hitting the glass ceiling at the top of their professions their future earnings before retirement are slightly curtailed [7].

CONCLUSION

Women are breaking down stereotypes of male/female jobs. Cracks are in the ceiling and women are moving up the corporate ladder. Yet, the glass ceiling being broken is a manifestation of success by too few women in the perpetual struggle for equal access and equal opportunity.

Certainly, women are still facing resistance in conservative business cultures, but they are definitely penetrating the glass ceiling in greater numbers than in the past; they are getting more education and training to prepare themselves for possible opportunities; and they are exhibiting a willingness to overcome obstacles or barriers to reach their career goals. But glass ceilings still exist. When glass ceilings are shattered forever, only then will we have succeeded in using our greatest asset – the people- to their fullest potential.

Does this mean that our nation is ready for a female president? That may be pushing the envelope a bit too far, but the literature does suggest that trends toward women enjoying greater success in an increased number of top management positions will continue throughout this decade, even though gender-pay gaps may exist. The glass ceiling is definitely being penetrated more frequently than ever before. Whether or not the business world is preparing to receive the greater numbers and whether or not families will suffer as a result, remain to be seen and both issues are subject to more research and study.

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STRATEGIES FOR MANAGING THE BOUNDARIES BETWEEN WORK AND FAMILY FOR HOME-BASED BUSINESS OWNERS

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ABSTRACT

Research shows that despite the fact that many entrepreneurs choose home-based business to better balance their work and family roles, many still experience work-family conflict. In this paper we discuss strategies for managing work and family integration. As the role integration entrepreneurs experience from running a business from home causes boundaries to become more blurred, it is necessary to actively manage these boundaries. Our model of boundary management for home-based business owners groups strategies into three categories: Personal, Planning, and Cultural.

Key Words: Entrepreneurship, Home-based Business, Work-Family Conflict, Boundary Management

INTRODUCTION

With the advent of information technology, more and more individuals are working from home and the integration of work and home has become easier and more acceptable. Although the view that home and work should be kept separate has been the norm for most of the industrial revolution, that view is unrealistic as it is impossible to keep the two worlds separate.

Although work-family integration has obvious benefits, there are also costs [2], which have to be minimized. Home-based business owners experience work-family conflict to a great extent. Our paper suggests strategies for minimizing such costs and answers the following questions: How does an entrepreneur (who assumingly) is highly committed to business, balance work and family life? Is it easier or more difficult than for the typical employee? How does an entrepreneur transition from the role of owner/boss to parent/spouse? How do they psychologically and physically move from one role to another?

The full manuscript consists of the following sections:

HOME-BASED BUSINESS IN THE INFORMATION AGE

In this section we discuss roles and issues resulting from the increasing number of home-based businesses in the information age. There are obvious benefits to the integration available in the information age, including more flexibility. These benefits are one of the reasons an increasing number of individuals are leaving the corporate world to start their own businesses. They see starting a home-based business as more integrative and therefore, as an opportunity to better balance their work and family lives.

LITERATURE REVIEW OF ROLES AND BOUNDARIES

In this section we discuss the literature related to work and family roles. We define role segmentation and role integration. Roles can be placed on a continuum ranging from high segmentation to high integration [2]. Segmented roles are inflexible and have impermeable boundaries and a high contrast in role identities [2]. Integrated roles are flexible and permeable and have a low contrast in role identities.

Roles in general are becoming more integrated. In this section, the benefits and costs of integration are reviewed. For example, there is more flexibility and permeability and it is easier to go from one role to another, but the boundaries between the roles become increasingly blurry.

In addition, we discuss role identification and how identification with a role can be high or low. When identification with both work and family roles are high, it is likely to lead to work-family conflict.

ROLES AND BOUNDARRIES APPLIED TO HOME-BASED BUSINESS OWNERS

In this section we discuss role integration and role identification of home-based business owners. Much of the entrepreneurship literature suggests that one shouldn't treat work and family as separate entities, which would imply integration. As noted above, roles in general are becoming more integrated, this is especially true for individuals who have home-based businesses because they have high role identity with their work role. Their work role is who they are so they cannot ever completely separate from it. So not only are the changes in society increasing integration for home-based business owners, but by role definition they also experience high role integration.

However, very few business owners, 17% of male and 37% of female business owners, give themselves an "A" grade in striking the balance [3]. Research shows that despite the fact that many entrepreneurs chose home-based business to better balance their work and family roles, many are still experiencing work-family conflict. One way to deal with the work-family conflict associated with highly integrated roles is boundary management.

HOME-BASED BUSINESS BOUNDARY MANAGEMENT

In this section we discuss strategies for managing work and family integration. As the role integration entrepreneurs experience from running a business from home causes boundaries to

become more blurred, it is necessary to actively manage these boundaries. According to boundary theory [4], [5], [6] individuals create and maintain boundaries between roles in order to make roles clearer and to create order. Some people allow boundaries to be crossed over more easily than others, where as some use boundaries to clearly keep roles separated [5]. Boundaries can thus help to keep roles delineated and separate [1] and allow one to clearly know and concentrate on which ever role they are in [5].

Our model of boundary management for home-based business owners groups strategies into three categories: Personal, Planning, and Cultural. Personal strategies include teleworking, using available technology, scheduling, and prioritizing. Cultural strategies involve creating a family friendly culture. Planning strategies involve addressing hard questions ahead of time, setting reachable goals, and having a life plan.

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MANAGING ORGANIZATIONAL CRISES: STRATEGIC RESILIENCE OR ORGANIZATIONAL CHAOS?

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ABSTRACT

This action research paper submission describes the importance of developing a contemporary theoretical model, and innovative, strategic, crisis management action plan, as necessary tools for navigating organizational transitions and organizational recovery, during traumatic events and tumultuous periods of organizational change, pertaining to the individual, group and team, as well as, the organizational systems-wide levels of analysis.

Keywords: Change, Crisis Management, Organization Development

INTRODUCTION

Given today's socio-political landscape and its' impact on contemporary organizational operating environments, companies must be prepared to respond to "extra-organizational" traumatic events, such as terrorism and bioterrorism. The best way to manage different types of organizational crises is to develop and design a well crafted Strategic Crisis Management Plan (SCMP), which is preemptive, and best protects an organization against a major unpredictable event.

A strategic crisis management plan provides employees with much needed reassurance that the organization and its' leaders are doing all they can to respond to the crisis. Based ongoing action research, the author posits that when employees have access to a strategic crisis management plan, that is driven by collaborative organizational expertise in strategic change, organization development and crisis management, these needed and requisite organizational skills, then, create a positive response and restorative psychological well being between organizational leaders and their organization stakeholders; by restoring a sense of order, with a purpose, a plan (to protect the organization), the psychological impact on employees and organizational morale, is considerably reduced.

While working as a management consultant in industry, having worked with several companies dealing with tragic aftermath, pertaining to the tragedy of the TWA airplane crash in 1996, resulting in numerous deaths, as well as, the terrorist attacks on September 11th, 2001, at the world trade center, the author contends, that although no organization can predict the unexpected, particularly a terrorist attack, for example, however, it can produce a preemptive, strategic plan to counteract the organizational chaos that often ensues.

The answers to who's in charge, what to do, where to go, who to contact, and various alternative

solutions, are found in a strategic crisis management plan and carried out in crisis oriented strategic organizational communications. Nonetheless, this proposed action research, will also highlight the important distinctions between organizational crisis management and strategic crisis communications; namely, their formulation, execution and implementation.

This action research paper will also examine secondary research on the organizational recovery and organizational renewal efforts to demonstrate how an organizational response can reduce the psychological impact and what steps organizations can take to restore a sense of order and purpose in the workplace. Importantly, the author posits that the impact of strategically communicating with compassion and candor has a positive behavioral effect on the organizational healing process and recovery; speeding realignment of organizational operations, while optimizing organizational efficiency and organizational effectiveness during tumultuous periods of change.

Accordingly, strategic and compassionate communications in an organization not only lessens immediate suffering of those directly affected by the trauma, but, it enables them to recover from future setbacks more quickly and effectively; it increases their attachment to their colleagues, restores an assurance of a steadfast psychological contract and restoration of the company itself.

Finally, following the large-scale traumatic event of September 11th, 2001, in New York City, the author argues that, in the initial stages of a crisis, the success of an organization's recovery process is twofold: Organizations that communicate swiftly, strategically and compassionately to their employees reduce the psychological impact and, organizations that provide access to a well-designed strategic crisis management plan, restore organizational confidence and provide strategic organizational resilience, rather, than organizational chaos.

In conclusion, during an organizational crisis, an organization's operating environment influences the way people perform their jobs, relate to their co-workers and interact with customers. Once a crisis occurs, the degree of organizational performance declines and the degree of recovery will likely vary between organizations. An organization's performance then depends on its' ability to prevent a crisis, and also it's' ability to respond and adapt to a crisis if one occurs. In the face of major organizational crises, the importance of being able to manage the organization's operating environment becomes critical to the successful implementation of a strategic crisis management action plan.

Consequently, the current pilot study will be undertaken to explore and develop a theoretical model for using the operating environment strategically; crafting an organizational strategic crisis management action plan, to assess how best to cope and adapt to organizational crises as a consequence of change, and how to improve organizational performance. Moreover, the present study seeks to examine which assessment tools organizations may use to strategically have a crisis resilient operating environment, as a critical capability for avoiding crises, surviving them when they occur, and thriving organizationally thereafter.

References available upon request from Mary Elizabeth Moran

THE BCG MODEL AND THE SWOT ANALYSIS REVISITED

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ABSTRACT

The Boston Consulting Group (BCG) portfolio matrix uses the industry's growth rate and the firm's market share as the main determinants in the classification of strategic business units. This paper proposes an additional dimension, the market size, for allocating the firm's resources among business units in a global environment. More particularly, we consider the benefits from using the modified BCG model in combination with a "SOWT" framework for teaching strategic assessment and development.
Keywords: strategy, assessment, frameworks.

INTRODUCTION

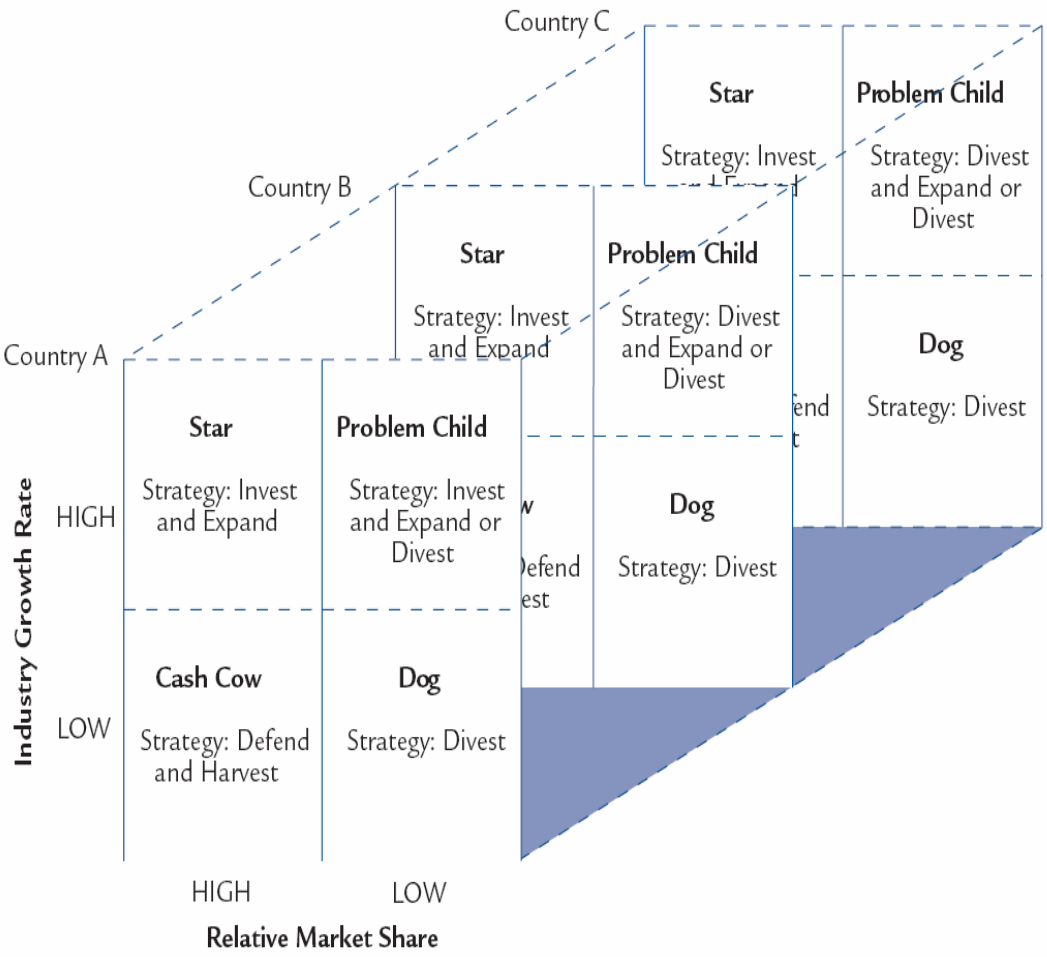
This paper proposes the use of an expanded BCG model in combination with a "SOWT" framework (Strengths, Opportunities, Weaknesses, and Threats) for strategic assessment and development. The BCG portfolio matrix uses product/market considerations as the primary basis for identifying strategic business units (SBUs). The industry's growth rate and the firm's market share are the main determinants of the strategic classification of the SBUs into four main quadrants, as shown in Annex 1.

THE FRAMEWORKS

We expand the BCG model by introducing a third dimension, the market size, which could help in allocating the firm's resources among business units in a global environment (Annex 2). Because of this added dimension, a separate framework should be used for each international business unit.

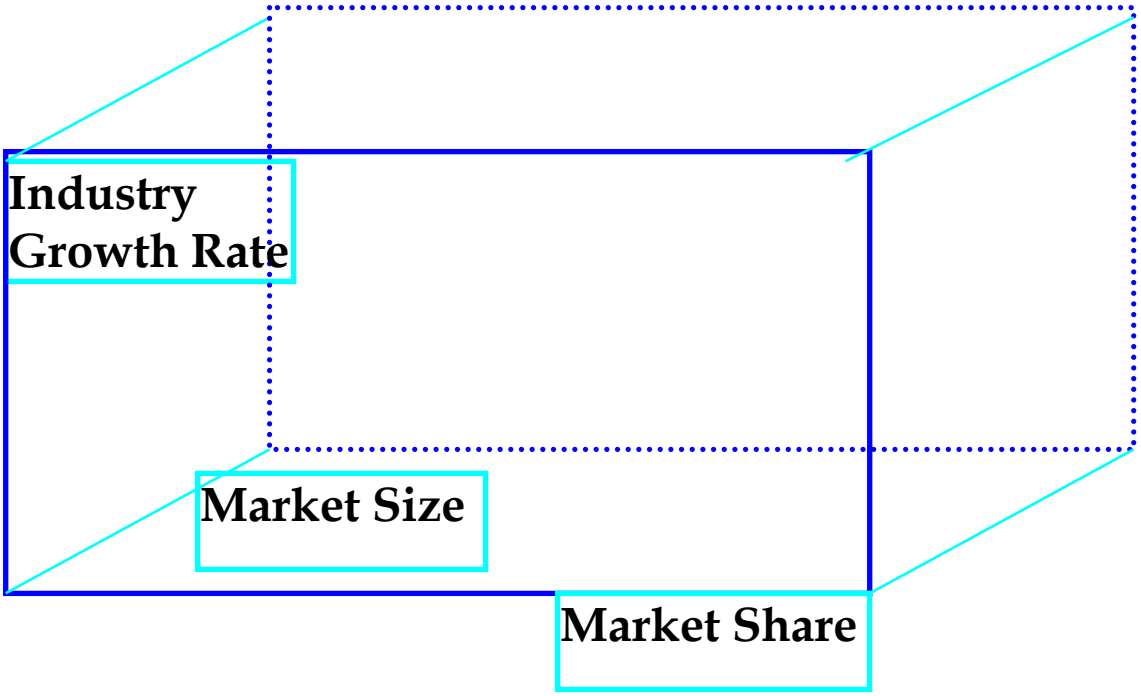
As Nicholls (1995) argued, organizations still have to decide how to allocate their scarce resources among a number of competing claims. The industry growth rate and the market share are helpful in assessing the competitive posture of a firm. However, the potential cash flows and revenues derived from the resources consumed need to be estimated. They also have to be translated in the home currency of the firm. In a given situation, although the market growth and the firm's market share could be promising, the size of the market may not offer a sufficient revenue base. Hence, the size of the market becomes a relevant variable in evaluating the strategic position of the firm. In Annex 3 we provide an example of sales forecasts translated in the firm's home currency. Sales projections are first computed in the foreign currency as follows: (market size) x (market share) x (1+market growth rate). Then we convert the international sales in the home currency.

Annex 1



The Boston Group Model

Annex 2



The Modified Boston Group Model

ANNEX 3

SCENARIO BUILDING - PER MARKET SEGMENT OR COUNTRY

MARKET GROWTH Example- Assumptions:	**EXPECTED** [1]	**Probability** [2]	**Weighted Forecast** [1] x[2]
SCENARIO 1	0.15	0.20	0.03
SCENARIO 2	0.10	0.50	0.05
SCENARIO 3	0.07	0.30	0.021
		1.00	**0.101**

MARKET SHARE	**EXPECTED** [1]	**Probability** [2]	**Weighted Forecast** [1] x[2]
SCENARIO 1	0.15	0.50	0.075
SCENARIO 2	0.1	0.20	0.020
SCENARIO 3	0.07	0.30	0.021
		1.00	**0.116**

MARKET SIZE **[In LOCAL CURRENCY]**	**EXPECTED** [1]	**Probability** [2]	**Weighted Forecast** [1] x[2]
EX:	**EUROS billion**		**EUROS billion**
SCENARIO 1	125	0.20	25
SCENARIO 2	200	0.50	100
SCENARIO 3	500	0.30	150
		1.00	**275**

SALES PROJECTIONS:
MARKET SIZE x MARKET SHARE x [1+ MARKET GROWTH RATE]

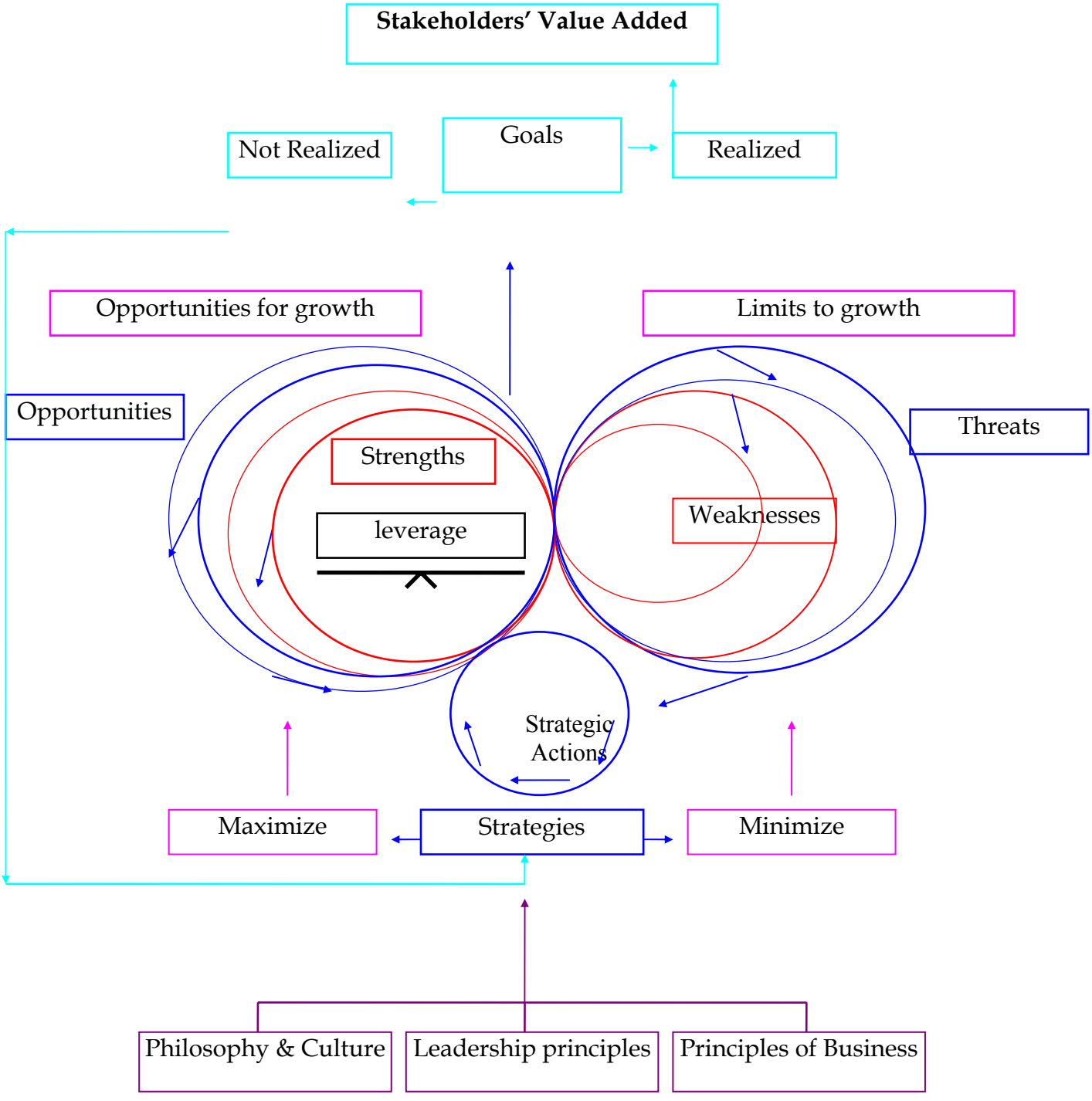
PROJECTED VALUE OF [LOCAL CURRENCY/HOME CURRENCY]

	EXPECTED [1]	**Probability** [2]	**Weighted Forecast** [1] x[2]
SCENARIO 1	0.83	0.20	0.166
SCENARIO 2	0.87	0.50	0.435
SCENARIO 3	0.90	0.30	0.27
		1.00	**0.871**

CONVERT IN HOME CURRENCY: **SALES PROJECTIONS IN US$**
Ex: 275 EUR/ [.87 EUR/$] 316.09 IN US$

BASED ON SALES PROJECTIONS,
WE CAN ESTIMATE THE PROFIT MARGIN
USING SCENARIO BUIDING

Annex 4 - The SOWT model



In this paper we also propose the use of the modified BCG model in combination with a "SOWT" framework developed earlier by Grandmont-Gariboldi (2005). As shown in Annex 4**,** "SOWT" model involves five wheels representing respectively the strengths and opportunities on the left side [SO], the weaknesses and threats [WT] on the right side, and in the middle, the strategic actions that can be used to maximize the SO and minimize the WT. The critical part at the center of the SO wheels is the firm's area(s) of leverage. In normal circumstances, focusing on the strengths and opportunities should allow to minimize weaknesses and threats. This is why the small circle is adjacent to the SO circles. The likely shrinking effect on the threats and weaknesses is reflected in the decrease of the size of the WT circles. The initial dimension of each circle and the firm's main area(s) of leverage can be determined based on quantitative and qualitative analyses of the firm's strategic posture. Adjustments in the relative size of each circle can be estimated for instance using percentage changes in performance measures such as market share, return on assets, unit cost, etc. The idea is to avoid a defensive approach, which focuses on threats and weaknesses and presents the risks of developing vicious circles of actions-reactions involving the firm and its competitors. However, some weaknesses and threats may never be eliminated because, as side effects, they may have to be included as inherent parts of the process as a whole. In addition, the model allows shifting the small circle to the right in particular cases, such as crisis situations.

The frameworks we propose in this paper could be used as workable tools in analyzing the strategic posture of a firm and in identifying areas of leverage for added stakeholders' value. They can be easily adapted to particular situations. They also allow interactive inputs from students in the traditional or virtual classroom

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INVENTORY BALANCING OF POST-USAGE COMPONENTS OF A DISASSEMBLY LINE

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ABSTRACT

In recent years, disassembly has gained a lot of attention due to its role in efficiently recovering valuable materials, parts, and subassemblies from end of life (EOL) products. This is due to the rigid environmental legislation, the economical and environmental benefits from reusing primary materials instead of virgin resources and the increase in environmental awareness and concerns of the consumers. However, the practice of recovering components and materials is challenging, as there are many associated complications that are unique to the disassembly process such as monitoring and controlling the inventory of core products and disassembled parts and the ability to satisfy demand from on hand inventory. Due to the disparity between demands for parts and their yields, there are many inventory problems that arise during the disassembly line balancing process. In this paper, we address the balancing of the inventories generated at various workstations of a so called "balanced" disassembly line.

Keywords: Disassembly line, Inventory control, End of life products, Inventory balancing, optimization

INTRODUCTION

In today's fast moving market, many of consumer products are subjected to disassembly (demanufacturing) and remanufacturing [1]. Thus the establishment of disassembly and remanufacturing facilities are necessary to handle the overwhelming number of products retrieved every year. According to a forecast, almost 50 million computers are expected to be discarded every year in the U.S. alone. So, for these facilities to be profitable, we have to develop models and techniques to help optimize their operations. Of course, recovery of value from an EOL product can only occur if the components can be easily extracted and subsequently sold at a profit [2]. In the U.S. most original equipment manufacturers (OEMs) have no interest in collecting used products and recovering components, in the absence of mandatory take-back legislation. This dissuades them from taking ownership of the life-cycles of their products [3]. Some of the factors that encourage such behavior are: i) Less vertical integration, ii) Significant uncertainties of quality and quantity of returned items, iii) Lack of efficiency of the product recovery process, and iv) Questionable profitability from product recovery [1].

Based on the aforementioned argument, an opportunity exists for smaller companies to enter the arena of product recovery by establishing stand alone facilities which, because of their smaller sizes, can operate on smaller scale, assume greater risks and have the flexibility to be "agile" to adapt to different products. However, there are many challenges associated with a disassembly line. Table 1 summarizes some of the differences between an assembly line and a disassembly line [4].

Table 1: Assembly Line vs. Disassembly line

Characteristics	Assembly Line	Disassembly Line
Process Flow	Convergent	Divergent
Condition of components	known	unknown
Inventory Challenges	Low-Moderate	High
Degree of Uncertainty	Low	High
Demand	Last Station	All stations

In this paper, we address the problem of balancing the inventories generated at each workstation of a disassembly line. This research, and future research, will address the balancing issue and suggests how to manage excess inventories and minimize their impact on the performance of the disassembly line and maximize its profitability. The objective is to find the right balances such that the demands are satisfied and the costs are minimized. An example consisting of a simple PC module is considered to illustrate the approach.

PROBLEM DEFENITION

One of the most challenging issues faced by a disassembly (demanufacturing) facility is the management of its inventory. In reverse logistics environment the control and monitoring of incoming and outgoing products and parts are more difficult than traditional methods in a supply chain network. The inventory problem in the reverse supply chain network stems from the disparity between the demand for disassembled components/materials and the actual line yields. Workstations tend to experience different accumulation rates as well as different depletion rates because of differences in their demands. Such differences create “uncertainties” in inventories and space requirements at the workstations. It is therefore necessary to develop a method to determine appropriate inventory levels, their upper and lower bounds, and ways to handle and maintain work-in-process (WIP) at suitable levels.

Most of inventory related issues addressed in the disassembly literature ignore the uncertain characteristics stemming from the probabilistic returns, the quality of returned items, varying recovery rates, changing demands and the logistical needs to support the disassembly facilities.

Because of the differences in flow rates (in and out) disassembled components start piling at the sorting area designated at each workstation. In some cases, this behavior does not interfere with the work because of the component(s) size and quick turn over. In other cases, the accumulation of inventory could block the workstation. The unexpected behavior of products returns or the sudden change in demand levels could lead to excess or shortage in inventory levels. The challenge is to manage the inventory of disassembled components to satisfy demand and carry minimum amount of components on hand during all time.

The inventory problem discussed here is unique because it only investigates the effect of inventory accumulation at the workstation, which is separate from the actual inventory that is stored at the warehouse facility. The goal is to keep optimum stock of each component type at each workstation.

Disassembly line inventory problem is defined as follows: A disassembly line is designed to disassemble one type of product that has *n* components. Disassembly task times, cycle time, precedence relationships and demand are known. However, there is uncertainty associated with the quality and the quantity of recovered components and/or subassemblies. The objective is to balance the inventory generated from each workstation by siphoning off the components materials disassembled by providing a proper flow to demand sources, thus minimizing the disparity between the actual demand and line yield (deviation) and/or optimizing some measure of performance. Figure 1 show an example of a disassembly line with components recovered in different rates.

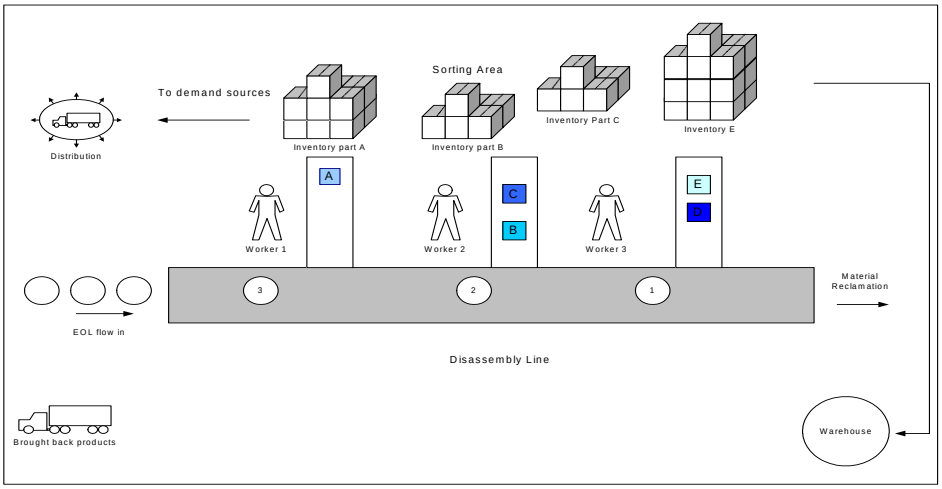

Figure 1. Disassembly line diagram with product recovery, *WS=3 and n=5*

Each part/subassembly is disassembled in one and separate workstation. At each workstation there exists two storage bins: Recoverable bin to store disassembled parts and recyclable bin for parts that do not pass the inspection. Parts disassembled are assumed to be sent directly to demand sources. Excess parts are either kept at the storage bin if there is enough space or sent to the storage facility.

Our research will investigate this behavior and the effect of some restrictions of the line specifications such as available bin space at the workstations, minimum on hand inventory required at each bin, and a limit on disposal volume per day, etc on how to balance the inventory. The proposed methodology will be further validated in future research and under different scenarios and compared to other approaches.

DISASSEMBLY INVENTORY MODEL WITH LINE RESTRICTION

Workstations in a disassembly line are the entities where disassembly operations take place. Each product is routed through all workstations and is delayed a predefined cycle time to allow worker to perform required actions. Then, disassembled part or subassembly is placed in a recoverable bin (storage bin) if it passed the inspection, otherwise it will be collected in a recyclable bin (storage bin).

The balance of the product will be sent to a down stream workstation until all parts are disassembled. In this paper, we will study the inventory problem of disassembled components and we will develop a simple model to balance the inventory at workstations in such way that the utilization of the spaces is similar and demand is satisfied.

The disassembly line has *M* workstation, with maximum capacity of *W* cubic units per bin per workstation. Each component type disassembled on the line consumes a certain amount of space w_i [5]. At any pointy in time the following relation must hold true:

$$\lambda_i * w_i \leq W \text{ ……. (1)}$$

Where λ_i is the amount of inventory of part type *i* at the specified recoverable bin (storage bin) any given point in time. At the end of period the following must hold true:

$$I_i * w_i \leq W \text{ ……. (2)}$$

By assuming that each workstation have a limited bin space that can carry a maximum inventory up to *I** components, where I_i^* is the maximum inventory of type *i* at the workstation, then

$$I_i^* = W \big/ w_i \text{ ……. (3)}$$

Assuming that recovery rate of each component type is given by γ_i, where *i*=1, 2, 3…*n* and *i* is the number of components in the core product. Also, assuming that $1-\gamma_i$ represents the disposal rate of part type *i*.

The line yield of each component type is calculated as follows:

$$\textit{Recoverable bin: } \lambda_i = Q^d * \gamma_i \text{ and } i = 1,2,3,...,n \text{ ……. (3)}$$

$$\textit{Recyclable bin: } \eta_i = Q^d * (1-\gamma_i) \text{ and } i = 1,2,3,...,n \text{ ……. (4)}$$

All recyclables of all part types *i* are collected in one storage bin, the recyclable bin, and sold at a predefined price. The mass (or volume) of recyclables can be calculated as follows:

$$\delta = \sum_{i=1}^{n} \psi_i * Q^d * (1-\gamma_i) \text{ ……. (5)}$$

Where ψ_i is the mass to unit (or volume to unit) mapping conversion. Also there is a non negativity constraints on all variables presented above.

Based on that, decision maker can balance the inventory at the workstations so that work is not interrupted due to limited space, and demand source starvation will not occur. The objective is to balance the space consumption so that

$$Iw_1 \approx Iw_2 \approx Iw_3 \approx ...Iw_n \text{ ……. (6)}$$

Next we will present our inventory model and how to correct any excess inventory of any part type after satisfying the demand.

THE MODEL

The Inventory mode in this paper is an extension to a previously proposed model. However, that model did not balance the inventory of each workstation by comparing its levels to other workstations along the line. The model presented here suggests keeping the inventories as low as possible while taking future periods in to account.

The first phase of the model is as follow:

1) Assign the following values: w_i, γ_i to all components *n* of the product disassembled. All products have exactly *n* components and w_i is expressed in cubic unit. The value of γ_i tend to decrease as the age of the product increase.
2) At $t = 0$, set initial inventory bins of all components and recyclable equal to zero , i.e., INV_A=0, INV_B=0, INV_C=0,…etc
3) Calculate the target level inventory of each part type, for all parts *n*.
4) For the set of possible Q^d values, where Q^d ranges between minimum and maximum values do the following:
   (i) Increase the disassembled quantity of each part by one unit
   (ii) Update the following values: λ_i, η_i, and *U*. The utilization rate *U* can be calculated using the following formula: $U = I_i * w_i$
   (iii) If $\lambda_i \geq D_i - I_i$, then excess inventory of part *i* exists
   (iv) Else, shortages in supply of part *i* exists

The second phase of the model is as follow:

1) If $I_i * w_i \leq W$, then go to next step. Else, liquidate the current inventory to appropriate level *S*, based on specific selling policy that generates the highest profit, while assuring future demand is met and enough space is available for incoming parts
2) In case of excess inventory, categorize on hand inventory of parts to three categories: A, B, and C. Class A: Good quality (for reuse, remanufacturing, and recycling), Class B: Good quality after rework (for remanufacturing, and recycling), and Class C: Imperfect quality (for recycling only)
3) Using a greedy algorithm, search all possible combinations of mixtures of parts that will generate the higher profit and subject to the following constraints:
   (i) For each *i*, there exists an appropriate level such that $L \leq I_i \leq U$, and $i = 1, 2, 3, ..., n$
   (ii) $I_i * w_i \leq W$ at all times
   (iii) $U_1 \approx U_2 \approx ... \approx U_n$

(iv) $D_{t+1} \approx E\left[\lambda_{t+1}\right] + I_{i,end\_of\_t}$

CONCLUSIONS

In this paper we discussed the problem of balancing inventory in a disassembly line. Managing inventory is an important aspect of managing a business and developing the right tools to do so is essential for firms involved in disassembly to ensure profitability. We extended previously reported models to balance the amount of inventory that is stored at the workstation bins along the disassembly line. This model takes the probabilistic nature of the problem into account and offers the ability to consider future demands. It also allows on hand inventory to be categorized into three different categories.

In future research the model will be validated under a multiperiod scenario and results will compared under different selling policies. However, some parts of the model still need to be developed such as finding the lower and upper bound constraint for the inventory level, and developing the right expression for finding the number of products to be disassembled.

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GENERATING A DISASSEMBLY-TO-ORDER PLAN

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ABSTRACT

The main objective of this research is to effectively solve a disassembly-to-order (DTO) problem. DTO is a system where a variety of returned products are disassembled to fulfill the demand for specified numbers of components and materials. Therefore, the optimal DTO plan must be generated in order to satisfy all demands, as well as to maximize profit and minimize costs of the system. Techniques implemented to solve the problem are Genetic Algorithm (GA), Linear Physical Programming (LPP) and refining algorithm. In this paper, we describe how GA and LPP techniques together with a refining algorithm can be combined to solve for the optimal numbers of take-back products. A numerical example is considered to illustrate the methodology.

INTRODUCTION

In recent years, wastes generated at the end-of-life (EOL) of electronic products have grown incredibly large. Due to the customers' desire to acquire products with latest technologies, millions of tons of electronic products, from cell phones to computers, are forced to be prematurely outdated and are dumped in landfills each year. The majority of the products discarded are otherwise in good functioning conditions. Therefore, an appropriate waste management is indispensable in order to prevent and diminish electronics wastes which cause negative impact on the environment.

There are several ways to manage EOL products. The most common choices are remanufacturing, reusing, recycling and disposing. Among these, disposal is the least desirable option as it causes reduction in the number of landfills and is harmful to the environment. Remanufacturing, reusing and recycling, on the other hand, can help decrease the rate of depletion of natural resources and help manufacturers save on disposal cost. Governments, manufacturers and consumers are aware of such problems. This has led to the implementation of several environmental regulations.

For remanufacturing, reusing and recycling, the components and materials must be obtained from EOL products through the disassembly process. In this paper, we focus on solving the disassembly-to-order (DTO) problem where EOL products are taken back from last users to be disassembled to fulfill the demands of components and materials. The objective is to generate the DTO plan, which includes the optimal numbers of take-back products, the numbers of products to be sent through each disassembly process and how to disassemble them. The solution must be generated in a way that it can satisfy all the demands while trying to achieve aspiration levels on profit and costs of the system, as well as to minimize the environmental impact.

This paper is organized as follows. In the next section, we provide a brief review of the relevant literature. Then we describe the DTO system and state the problem. After that, we introduce techniques implemented to solve the problem, which are followed by a case example. Finally we provide some conclusions of our work.

LITERATURE REVIEW

Disassembly has recently been studied by many researches. A recent book by Lambert and Gupta [9] is helpful in understanding the general area of disassembly. We briefly summarize some of the relevant literature that is useful for this paper.

Boon, Isaacs and Gupta [2] provided a net profit function for recyclers to investigate and report the factors that most influence the profit, and to assess the effect of changes in different variables on recycler's profits. Jung and Bartel [7] presented an economic analysis for used equipments in computer take-back and recycling process. Inderfurth and Langella [6] introduced an approach for solving the disassembly-to-order problems under stochastic yields. Yano and Lee [14] presented a review of lot sizing strategies with random yields. Linton [10] proposed options and obstacles on managing electronic products at their end-of-life. Moyer and Gupta [13] presented a survey of works related to environmentally conscious manufacturing, recycling and complexity of disassembly in the electronics industry. Ellis [3] presented a review based on environmental issues in electronics manufacturing.

Literatures related to the techniques presented in this research are as follows. Messac, Gupta and Akbulut [12] introduced a new approach (viz., linear physical programming) to solve multiple objectives optimization problem. Altiparmak, Gen and Lin [1] proposed a Genetic Algorithm to design multi-product multi-stage supply chain networks and investigate its effectiveness and efficiency on different size problems. Kongar and Gupta [8] applied Genetic Algorithm to solve disassembly sequencing problem. McGovern and Gupta [11] presented Genetic Algorithm for obtaining optimal or near-optimal solutions for disassembly line balancing problems.

DISASSEMBLY-TO-ORDER SYSTEM

Disassembly is the process of systematic removal of the desired components or materials from the original assembly so that the components or materials are obtained in the desired form. In a DTO system, varieties of EOL products are taken back from the last users to the disassembly facility and are disassembled to satisfy the demands for components and materials. In this paper, we consider several types of disassembly which are selective (only selected items are disassembled), complete (all items are disassembled), non-destructive (focusing on items rather than materials) and destructive (focusing on materials rather than items) disassembly.

The DTO process starts with the retrieval of take-back EOL products from collectors. Depending on the condition of the EOL products, some of them are sent to disposal. The rest (majority) of them are disassembled, using either destructive or non-destructive disassembly. The components yield from non-destructive disassembly is stochastic. The components obtained are in either good working condition or broken. Good components are used to satisfy the demands for used components. Additional components may be supplemented from outside suppliers to satisfy the demands. Bad components, together with materials from destructive disassembly, are sent to the recycling process, either in-plant or out of plant, to satisfy the demands for materials used for recycling. In-plant recycling is limited to the available in-plant capacity. Since it is difficult to recover all the materials from all the components recycled, the yields are stochastic. Components that exceed the demands are sent to disposal along with the waste materials from the recycling process.

In the next section, we present techniques and discuss how they can be applied to solve the DTO problem. First, to generate the optimal numbers of take-back products, we introduce a technique which is a combination of Genetic Algorithm (GA) and Linear Physical Programming (LPP). This technique

combines the advantage of GA which greatly reduces complexities of solving high-level complex problems and the advantage of LPP which efficiently manages multi-objective problems with vagueness. After that, we present a refining algorithm which rearranges the flow of the products and then generates a DTO plan which includes the optimal number of products to be sent to each disassembly station, the number of products to be completely disassembled and selectively disassembled, and also how to selectively disassemble them. This helps ensure the maximum benefit of the disassembly process by reducing the number of procured and disposal components, thus leads to a higher profit.

PROPOSED TECHNIQUES

Phase 1: Generating the optimal numbers of take-back products

As stated in the previous section, we implement a combination of GA and LPP techniques to generate the optimal numbers of take-back products. GA is an adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics. Initially Genetic Algorithm starts with a set of randomly generated feasible solutions (in this case, the number of take-back products) which form the initial population. Each member of the population (each solution) is encoded as an artificial chromosome. Chromosomes are normally represented by a combination of numbers, alphabets and/or other characters, which contain information about the solution mapping. Each chromosome is then assigned a score based on a predefined fitness function. Basically chromosomes with better scores are chosen as parents to create the next generation of population by the hope of achieving a chromosome with the best score. For more information on GA and how GA can be applied to solve the DTO problem, see Imtanavanich and Gupta [4].

Since the chromosomes' scores are used to determine the parent chromosomes, fitness function has to be formulated in such a way that it accurately represents the objective of the problem. Generally the DTO problem is multi-objective and contains vagueness in aspiration levels of the goals. LPP, which is basically an optimization technique that has capability to represent the decision maker's preferences by implementing class functions and to efficiently manage multi-objective problem, is a very appropriate technique implemented as a fitness function. For more information on LPP, including the LPP model and how to implement LPP to the DTO problem, see Imtanavanich and Gupta [5].

In order to calculate score for each chromosome by using LPP, we basically plug in each chromosome (numbers of take-back products) to the LPP model, and then calculate the objective value (the summation of class functions of all goals) which will be used as the chromosome's score. According to LPP model, the best objective value is zero. Therefore, chromosomes which have scores closer to zero will be selected as parent chromosomes.

Phase 2: Refining the solution and generating the DTO plan

After we obtain the optimal numbers of take-back products, we apply the refining algorithm. First, we add a selective disassembly process and a mixed (non-destructive and destructive) disassembly station, which are excluded in the first model in order to reduce the significant amount of complexities in solving the problem. Then we rearrange the flow and generate the number of products to be sent through complete non-destructive, complete destructive and selective mixed disassembly stations, as well as the details on how to selectively disassemble the products. This algorithm prevents over-disassembled components caused by a complete disassembly process, thus greatly reduces the number of procured and disposal components and consequently leads to a higher profit.

CASE EXAMPLE

In this example, we consider four types of notebooks as take-back products. The structures of the products and important input data of the components are shown in the figure and the table below.

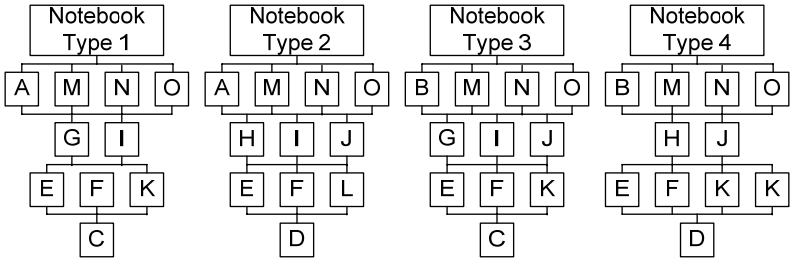

Figure 1. Product structures for case example

Table 1. Input data for the case example

Components	*Price of component*	*Dest. Diss cost*	*Non-dest diss cost*	*Disposing cost*	*Unit holding cost*	*Procurement cost*	*Disposing cost*	*Reuse Demand*	*Recycling Demand*
[A] LCD Monitor Type I	75	0.15	0.25	0.5	0.35	75.5	0.5	460	300
[B] LCD Monitor Type II	65	0.15	0.25	0.5	0.35	65.5	0.5	400	280
[C] Motherboard Type I	45	0.1	0.15	0.2	0.1	45.5	0.2	430	220
[D] Motherboard Type II	35	0.1	0.15	0.2	0.1	35.5	0.2	370	250
[E] Processor	50	0.05	0.1	0.15	0.08	50.5	0.15	730	340
[F] Memory	35	0.05	0.1	0.15	0.05	35.5	0.15	1590	350
[G] Harddrive 20Gb	40	0.1	0.15	0.25	0.15	40.5	0.25	400	200
[H] Harddrive 30Gb	50	0.1	0.15	0.25	0.15	50.5	0.25	440	250
[I] CD Drive	20	0.1	0.12	0.2	0.12	20.5	0.2	390	180
[J] Combo Drive	40	0.1	0.12	0.2	0.14	40.5	0.2	680	200
[K] Network Card	20	0.05	0.1	0.15	0.07	20.5	0.15	690	200
[L] Modem	10	0.05	0.1	0.1	0.11	10.5	0.1	650	220
[M] Keyboard	10	0.06	0.12	0.1	0.1	10.5	0.1	710	250
[N] Battery	35	0.05	0.1	0.15	0.06	35.5	0.15	710	210
[O] Power Adaptor	25	0.05	0.1	0.15	0.1	25.5	0.15	730	160

Take-back product costs for notebook type 1, 2, 3 and 4 are 300, 325, 360 and 350 respectively. More details on the input data can be seen in the similar case example in Imtanavanich and Gupta [4].

Phase 1: Optimal numbers of take-back products

First, we calculated the optimal numbers of take-back EOL products by using Genetic Algorithm (GA) and Linear Physical Programming (LPP) concept. In order to apply LPP, we defined range limits for each goal as given in the table below

Table 2. Range limits for each goal

Preference Level	Total Profit	Procurement Cost	Take-back Cost	Disposal Cost
Ideal	> 60000	< 56000	< 420000	< 350
Desirable	(58000, 60000)	(56000, 58000)	(420000, 435000)	(350, 400)
Tolerable	(56000, 58000)	(58000, 60000)	(435000, 450000)	(400, 450)
Undesirable	(54000, 56000)	(60000, 62000)	(450000, 465000)	(450, 500)
Highly Undesirable	(52000, 54000)	(62000, 64000)	(465000, 480000)	(500, 550)
Undesirable	< 52000	> 64000	> 480000	> 550

After having all the input data, the GA process started. The process was set to be terminated when it has evolved for 1000 steps or there has been no improvement for 500 steps (whichever comes first). After evolving for 559 steps, stopping condition (viz., no improvement for 500 steps) was met. The total run time was approximately 4 seconds. The optimal numbers of take-back product type 1, 2, 3 and 4 were 241, 261, 400 and 321 respectively. Profits and costs calculated are shown in table below.

Table 3. Profit and costs achieved from the optimal solution

Goals	Aspiration level	Actual Value
Total Profit	**>≈ 60000**	61580.16
Procurement cost	**<≈ 56000**	55667
Take-back Cost	**<≈ 420000**	413825
Disposing cost	**<≈ 350**	133.7

Phase 2: Generating a DTO plan

After we included selective disassembly process and mixed disassembly station, and then rearranged the flow of the products and generated the DTO plan. The results are as follows.

Table 4. The number of products sent to each process

Product	**Type 1**	**Type 2**	**Type 3**	**Type 4**
Number of take-back products	241	261	400	321
Number of good-for-disassembled products	236	253	396	315
Send to				
Complete Non-Destructive Disassembly	236	68	186	165
Complete Destructive Disassembly	0	0	5	0
Selective Mixed Disassembly	0	185	205	150

For products sent to selective mixed disassembly station. The details are summarized in the table below.

Table 5. The details on how to selectively disassemble the products

Product 2 (From 185 Units)	Non-Destructive	Destructive	Ignore
110 Units	A,D,F,H,L,N	E,I,J,M,O	-
25 Units	A,D,F,H,I,L,N	J,M,O	E
19 Units	A,D,F,H,I,L,N	J,M,O	E
19 Units	A,D,F,H,L,N	E,J,M,O	I
12 Units	A,D,F,H,I,L,N	E,J,M,O	-
Product 3 (From 205 Units)	Non-Destructive	Destructive	Ignore
107 Units	E,F,J,K,O	B,C,G,M	I,N
19 Units	E,F,J,K,O	B,C,G,I,M	N
18 Units	C,F,G,J,K	B,I,N	E,M,O
15 Units	C,F,G,J,K	B,I	E,M,N,O
14 Units	F,G,J,K,O	B,C,I	E,M,N
13 Units	E,F,J,K,O	B,C,G,I	M,N
10 Units	F,J,K,O	B,C,G,I	E,M,N
9 Units	C,F,G,J,K,O	B	E,I,M,N
Product 4 (From 150 Units)	Non-Destructive	Destructive	Ignore
105 Units	B,F,J,L,M	D,E,H,K,N	O
14 Units	B,J,K,L,N	D,E,H,M	F,O
14 Units	B,J,L,M	D,E,H,K,N	F,O
12 Units	B,J,L	D,E,H,K,M,N	F,O
5 Units	B,J,L,N	D,E,H,K,M	F,O

Profit and costs achieved after refining the solution are as follows.

Table 6. Profit and costs after refining the solution

Goals	Before	After
Total Profit	61580.16	65098.39
Procurement cost	55667	52236.47
Take-back Cost	413825	413825
Disposing cost	133.7	46

CONCLUSIONS

In this research, we presented techniques to solve a disassembly-to-order problem. Since the objective is to satisfy all demands, as well as to maximize profit and minimize costs of the system, the numbers of take-back products are the most important and have to be optimally generated. Implementing a combination technique of Genetic Algorithm and Linear Physical Programming helps reduce the complexities of solving high-level decision making problem and helps manage multiple objectives problem with vagueness. In addition, refining the solution by considering selective disassembly and mixed disassembly station makes the problem more realistic and eliminates over-disassembled components caused by a complete disassembly process, thus resulting in a higher profit. The case example proves that the optimal solution is effectively achieved in a short time.

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DISPOSAL DECISIONS UNDER PREDETERMINED PRICING POLICIES

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ABSTRACT

The economic progress of product recovery facilities (PRFs) is often bogged down by the inventory imbalances arising from the hard-to-predict arrival rates of discarded products and the stochastic demand trends for the recovered components. In spite of adopting an effective pricing policy – a strategy to minimize inventory fluctuations – the inventory levels may skyrocket when there is an unexpected surge in the quantity of discarded products. Under this scenario PRFs have two options: either to dispose the surplus items or to stock them in anticipation of the future demand. This paper is concerned with PRF's optimal disposal decisions when the actual demand and the forecasted demand go out of sync, rendering the existing price policy suboptimal. The problem is modeled as a stochastic dynamic programming model. The analysis of the optimal disposal policy indicates that disposal is preferable when the carrying cost exceeds the disposal cost.

INTRODUCTION

The recent surge in the amount of discarded products and their environmental impact has led to legislations mandating manufacturers to take back discarded products. The overarching motive of these regulations is to require that the original equipment manufacturers (OEMs) accept the end of life products and encourage them to carry the environmentally benign activities such as, product reuse, recycle, and proper disposal. IBM's Global Asset Recovery Services [1], AER Worldwide [2], NuKote [3], and ReCellular [4] are good examples of product recovery facilities (PRFs). They face many daunting challenges which could dent their financial progress: (a) expensive and skilled labor required for product recovery operations; (b) uncertainty in the timing and quantity of discarded products arriving at the PRFs; (c) fleeting inventory levels of recovered components resulting from the unpredictable disposal of products and stochastic demand; (d) holding costs of surplus inventory; (e) lost sales due to stockouts; (f) disposal cost of leftover and obsolete inventory; (e) "fire-fighting" inventory clearance strategies such as promotional sales, discounts, markdowns, and donation to charities; (f) competition from OEMs, and (g) restrictive environmental regulations. Of all the challenges, inventory levels have a more telling effect on the revenue of PRFs. Uncertainty is induced into inventory management of PRFs by the unpredictable customer rate of product disposal, discarded product quantity, and arrival time at the facility. The uncertainty could lead to extremities of both kinds, too low inventory levels and too high. Both these states of inventory are detrimental to the profits of PRFs. A perpendicular rise in inventory levels could increase the carrying and subsequently the disposal costs. On the other hand, backorders could result in stockout situations. If inventory levels continue to remain high for longer periods of time obsolescence could catch up on the components [5] mitigate their sales opportunities. In case components become obsolete, the revenue from selling them as recyclable material could be smaller than their reuse revenue.

Appropriate pricing of components in inventory is one of the effective ways to address these challenges [5-9]. This strategy has a twofold impact: it facilitates inventory control and enhances the profit margin. In spite of adopting a clearance-friendly pricing policy, inventory levels may go beyond the desirable limits when, (a) there is an unexpected surge in the quantity of discarded products; and (b) there is inadequate demand for components. Although PRFs can adopt pricing policies which dynamically adjust prices according to the on-hand inventory level, implementing such policies involves cost to relabel products with updated prices and cost of communicating the updated prices to customer [10]. Moreover, implementing such a policy at a short notice may be difficult from an operational perspective. This work proceeds with the assumptions that, PRFs do not dispose product returns when they arrive unexpectedly, instead they are subject to product recovery operations; and PRFs do not implement a dynamic pricing policy.

When it becomes necessary for PRFs to control the inventory of recovered components, they have two choices: either to dispose or to stock in anticipation of the future demand. The decision depends on the holding cost, disposal cost, inventory level, and the forecasted demand. Disposals may not always be attractive; penalties could be incurred when the disposed quantity exceeds the regulated limit imposed by environmental regulations.

This research is aimed at answering the question, "what is the optimal quantity of items to dispose from recovered component inventories under a predetermined pricing policy?" This issue is addressed for a scenario that PRFs could encounter – the forecasted demand and actual market demand are so out of sync that the prices determined based on forecast demand would become suboptimal for the actual demand.

PREVIOUS RESEARCH

In the chronicled literature most research articles address disposal issues for items in recoverable inventory that stock discarded product returns. When these products are subjected to product recovery operations the ensuing components are stocked in serviceable inventories. Disposals from serviceable inventories may become necessary for products which normally require substantial product recovery operations and whose components have different demand patterns even though an effective price policy is in effect.

van der Laan and Salomon [11] determined the optimal reorder point, order quantity, and disposal quantity for an inventory system where returned products are first repaired and stocked to satisfy the demand. Inderfurth [12] addressed the disposal decisions when the product returns and the demand are stochastic. Inderfurth *et al*. [13] addressed the issue of allocating the returned products to the various remanufacturing options available and the ensuing disposal issues. van der Laan and Salomon [14] determined the optimal quantities to remanufacture, dispose, and procure for a product recovery system with push and pull production strategies. Teunter and Vlachos [15] determined the disposal quantity of returned products using simulation. Beltran and Krass [16] analyzed a variant of the dynamic lot sizing problem with backorders and excess inventory disposals. Guide *et al*. [17] developed optimal disposal strategies for returned products by basing their decision on the time to process returned products in the facility.

ANALYTICAL MODEL

PRFs usually post prices using a forecasted demand function which is normally determined by factoring in the current market conditions and historical demand data. The actual and the forecasted demand could be out of sync when the market dynamics influence or alter the customer purchase decisions. When this happens, the prices posted by PRFs could become suboptimal consequently the inventory may not be cleared as expected. Here, it is assumed that PRFs do not revise their price policy to optimality. In this section, the optimal disposal decision under such a situation is determined. Before delving into the modeling of the problem the setting of the problem is first presented.

A PRF starts off the selling horizon, which is equally divided into $N-1$ periods, with a certain inventory level. In any period, the following sequence of events takes place in that order. Inventory (serviceable inventory) is replenished, then the orders are fulfilled, and finally the disposal decision is made. The replenishment quantity, price, and demand are assumed to be known for every period. PRFs have to abide by a disposal regulation which restricts the quantity of serviceable inventory disposed to landfills to a pre-specified limit. On violation of the regulation a penalty is imposed. When demand exceeds the on-hand inventory the PRF does not entertain any backorders. It is assumed that the PRFs' inventory capacity is finite and the replenishment quantity cannot exceed this capacity limit.

This problem is best modeled by dynamic programming techniques [17] – the stages are represented by the $N-1$ periods of the selling horizon, the state variable is the inventory level of remanufactured components in each period, and the decision variable is the disposal quantity in each period. Let s_i be the inventory at the beginning of stage i, with $0 \le s_i \le M$, where M is the inventory capacity. The inventory level at the beginning of the next stage is $s_{i+1} = max\{0, s_i + r_i - \lambda_i - w_i\}$ where r_i, λ_i, and w_i respectively represent the replenishment quantity, demand, and disposal quantity in period i. It is assumed that the replenishment quantity is known for all periods. Let the price policy be $\{p_1, p_2, ..., p_{N-1}\}$ in the selling horizon which is already predetermined. Let d_i be a random variable that represents the demand in stage i. For modeling purposes, assume that d_i follows a Poisson distribution. The expected demand when u units are available in inventory is,

$$\overline{\lambda_i}(u) = \sum_{j=0}^{u-1} jP_j + u\sum_{j=u}^{\infty} P_j \qquad (1)$$

where, $P_j = \frac{e^{-\mu_i}(\mu)^j}{j!}$ and μ_i is the mean demand arrival rate, and $\overline{\lambda_i}$ is the expected demand in stage i.

The disposal decision arises only when there are leftover components from sale and the disposal cost, C_d, is cheaper than the holding cost C_h, i.e., $C_h > C_d$. Let w_i be the disposed quantity in stage i with $w_i \in [0, q]$, where $q = \min\{D, s_i + r_i - d_i\}$, D being the disposal limit according to the regulation. If however the disposal cost exceeds the inventory carrying cost then the cheaper alternative is chosen. The expected profit earned in stage i is,

$$z_i(s_i, w_i) = p_i\overline{\lambda_i}(s_i + r_i) - C_h(s_i + r_i - \overline{\lambda_i}(s_i + r_i) - w_i) - C_d w_i \qquad (2)$$

Using Bellman's optimality principle, the optimal expected profit from stage i through stage $N-1$ is,

$$J_i^*(s_i) = Max\, E\left\{ z_i(s_i, w_i) + \sum_{j=0}^{s_{i+1}} P(j/s_i, w_i) J_{i+1}^*(j) \right\} \tag{3}$$

In equation (3), $P(j/s_i, w_i)$ is the transition probability that the inventory level at stage i+1 is j when at stage i it is s_i. The transition probability is computed as,

$$P(s_{i+1}/s_i, w_i) = \begin{cases} P_{s_i + r_i - w_i - s_{i+1}} & \text{if} \quad M > s_i + r_i - w_i \geq s_{i+1} > 0 \\ \sum_{j=s_i+r_i-w_i}^{\infty} P_j & \text{if} \quad M > s_i + r_i - w_i \text{ and } s_{i+1} = 0 \\ 0 & \text{if} \quad M \geq s_{i+1} > s_i + r_i - w_i \end{cases} \tag{4}$$

The optimal disposal quantity in stage i which maximizes equation (3) is,

$$w_i^* = \begin{cases} \min\{D,\, s_i + r_i - d_i\} & \text{if} \quad C_h \geq C_d \\ 0 & \text{if} \quad C_h > C_d \end{cases} \tag{5}$$

The optimal disposal quantity in each stage is found by choosing the corresponding disposal quantities for $J_i^*(s_i), \forall i = 1, 2, ..., N-1$.

NUMERICAL EXAMPLE

Consider a selling horizon of 5 weeks ($N - 1 = 5$) with the replenishment quantity be {4, 2, 1, 2, 2}. Let the other parameters be C_h =\$5, C_d = \$4, M = 4 items, D = 10 items. Let the mean demand in each period be μ = 1 units per week and the predetermined price policy be {\$17, \$15, \$13, \$10, \$6}, where each element in the set represents the price posted for a week. The transition probability between states is shown in Table 1 and the optimal disposal policy is shown in Table 2. Also the optimal expected profit at the onset of the selling horizon is shown in Table 2. The expected profit is higher when more items are available in inventory.

Table 1: Transition probability

$s_i + r_i - w_i$	s_{i+1}				
	0	1	2	3	4
0	0.36	0	0	0	0
1	0.36	0.36	0	0	0
2	0.18	0.36	0.36	0	0
3	0.06	0.18	0.36	0.36	0
4	0.01	0.06	0.18	0.36	0.36

Table 2: Optimal disposal policy

$s_i + r_i$	w^*_1	w^*_2	w^*_3	w^*_4	$J^*_1(s_1)$
0	0	0	0	0	0.00
1	0	0	0	0	40.81
2	1	1	1	1	36.82
3	2	2	2	2	20.72
4	3	3	3	3	1.09

CONCLUSIONS

Achieving a proper inventory balance between the recovered components obtained from product recovery operations and the demand for recovered components is crucial for PRFs to prosper economically. This work addressed the question, how much to dispose from recovered component inventories when PRFs already have a price policy in place. This paper determined the optimal disposal policy for a commonly encountered scenario where the existing price policy is rendered suboptimal when the PRFs' forecasted demand differs significantly from the actual demand. Investigation of the optimal disposal policy indicated that disposal is the preferred choice when the cost to dispose is cheaper than carrying items in inventory.

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PERFORMANCE MEASUREMENT IN A CLOSED-LOOP SUPPLY CHAIN NETWORK

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INTRODUCTION

An effective management of supply chain is a key factor for the better realization of organizational goals and customer expectations. In the era of globalization of markets and business process outsourcing, many firms realize the importance of continuous monitoring of their supply chain's performance for its effectiveness and efficiency [1]. In the modern era, performance measurement has a far more significant role than just quantification and accounting. It provides the management important feedback to monitor performance, reveal progress, diagnose problems and enhances transparency among the several tiers of the supply chain thus making a phenomenal contribution to decision making particularly in re-designing business goals and strategies and re-engineering processes [2], [3]. Developing the performance measurement systems is a difficult aspect of performance measure selection. It involves the methods by which an organization creates its measurement system. Important questions that need to be addressed include: What to measure? How often to measure? How are multiple individual measures integrated into a measurement system? [4].

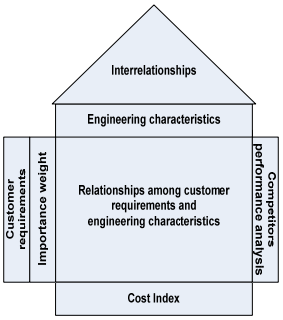
A reverse supply chain consists of a series of activities required to retrieve a used-product from a consumer and either recover its left over market value or dispose it off. The combination of traditional/forward supply chain and reverse supply chain forms the closed-loop supply chain (CLSC). While this process is mandatory in many European nations, it is still in its infancy in the United States. Due to the inherent differences in various aspects between the forward and the reverse supply chains, the performance metrics and evaluation techniques used in traditional supply chain cannot be extended to the reverse supply chains.

METHODOLOGY

In this chapter, we identify appropriate performance metrics and their enablers for a reverse/closed-loop supply chain environment and propose a linear physical programming (LPP) based quality function deployment optimization approach to evaluate a reverse/closed-loop supply chain network for its performance. A numerical example is considered to illustrate the methodology.

APPLYING LPP TO QFD

Quality function deployment (QFD) developed by Yoji Akao in the 1960s, links the customer requirements with design, development, engineering, manufacturing and service functions. QFD can be viewed as a comprehensive quality system for customer satisfaction. The house of quality (HOQ) (figure 1) shows the customer requirements, engineering characteristics, their interrelationships and the competitor's performance analysis. HOQ is used to assist in converting the customer's demands to substitute quality characteristics. Figure 2 illustrates the steps involved in applying LPP to QFD optimization [5]. The roof of the HOQ shows the interrelationships among the performance metrics ($=\gamma_{jk}$ correlation between the j^{th} and k^{th} performance metrics). These relationships are based on the knowledge and experience of the design team.



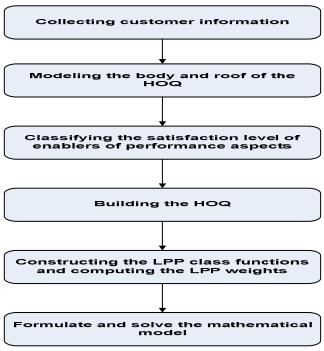


Figure 1. House of Quality **Figure 2. Steps in LPP-QFD Optimization**

The body of the HOQ shows the relationships between performance metrics and enablers. R_{ik} denotes the relationship between i^{th} enabler and j^{th} performance metric. These relationships are evaluated in a scale (1-9), while one represents the weakest relationship, nine represents the strongest relationship. In order to quantify the impact of the dependencies between the engineering characteristics on the relationship between the customer requirements, the model transformation shown in equation (10.1) is used.

$$R_{ij}^{norm} = \frac{\sum_{k=1}^{n} R_{ik}\,\gamma_{kj}}{\sum_{j=1}^{n}\sum_{k=1}^{n} R_{ij}\,\gamma_{jk}}, \; i = 1,2,...,\; m \; ; \; j = 1,2,...,\; n \qquad (1)$$

where, R_{ij}^{norm} can be interpreted as the incremental change in the level of fulfillment of the i^{th} enabler when the j^{th} performance metric is satisfied to a certain level; m is the number of enablers and n is the number of performance metrics. Using LPP, the satisfaction level of each customer requirement is classified in one of the six different ranges, namely, ideal, desirable, tolerable, undesirable, highly undesirable and unacceptable. The bottom of the HOQ shows the cost index (c_j) for each performance metric, which indicates the cost involved in achieving the maximum value of that performance metric.

PERFORMANCE METRICS AND ENABLERS IN A CLOSED-LOOP SUPPLY CHAIN

The following are the performance metrics (PM) and enablers were identified in our methodology:

1. *Reputation*: This metric deals with the firms overall reputation in the industry. It is driven by enablers such as on-time delivery ratio, returning customer's ratio, the firms 'green image' etc. Green image can be measured in a number of different ways like the environmental expenses incurred or the amount of waste disposed or the fairs/symposiums related to environmentally conscious manufacturing the firm participates in etc. In our methodology, we consider the amount of waste disposed to measure the 'green-image'.
2. *Innovation and Improvement*: This metric is driven by enablers such as R&D expenses ratio, the number of new products and processes launched etc.
3. *Public Participation*: This metric is a measure of the firms marketing capabilities can be driven by enablers such as flexibility, or the firm's ability to handle uncertainties, after sales service efficiency and the markets targeted (markets targeted is quantified as the percentage of customers that are knowledgeable about the firms product, the more knowledgeable the better is the participation and better can be the customer service). After sales service efficiency can be defined as the ratio between the number of customers, seeking customer service to the total number of customers served.

4. *Facility Potentiality*: Potentiality of the remanufacturing facilities can be driven by several enablers such as the location of the facilities, the increment in the quality of products remanufactured (=quality of outgoing – quality of incoming products), disassembly time multiplied by the throughput, throughput divide by the supply of used-products, usage of automated disassembly systems etc. We quantify *location* by specifying it as the distance from the customer/markets/or the nearest major city and *usage of automated disassembly systems* as the amount of money spent on automated disassembly systems.
5. *Responsiveness*: This metric reflects how well the firm responds to the ever-changing customer specifications, as well as their level of customer service and can be driven by enablers such as flexibility, or the firm's ability to handle uncertainties and the firms after sales service efficiency. We quantify *flexibility* by the number of different varieties of products the firm manufactures/remanufactures.
6. *Delivery Reliability*: This metric reflects how well the firm meets the due dates specified by the customers and can be driven by enablers such as the effectiveness of the firms master production schedule, the usage of automated disassembly systems, the supply of used-products, the quality of used-products etc. Effectiveness of firms master production schedule can be defined, as the ratio of the number of orders delivered no later than due date to the total number of orders delivered.

Other operational metrics such as resource utilization, cost per operating hour and manufacturing lead-time that are self-explanatory are also considered in our study. For brevity purpose, the performance metrics and enablers are not explained in detail.

MATHEMATICAL MODEL FORMULATION

The LPP problem is formulated as:

$$Minimize \quad \sum_{i=1}^{m} \sum_{s=2}^{5} \left[\tilde{w}_{is}^{-} d_{ps}^{-} + \tilde{w}_{is}^{+} d_{ps}^{+} \right] \tag{2}$$

where, $\tilde{w}_{is}$ represents the LPP weights obtained using the algorithm presented in [6], d_{ps} represent the deviations of the enablers from their target values.

Subject to

$$\sum_{j=1}^{n} R_{ij}^{norm} - d_{is}^{+} \le t_{i(s-1)}^{+} \quad and \quad \sum_{j=1}^{n} R_{ij}^{norm} \le t_{i5}^{+}, (for\ all\ i\ in\ classes\ \ 1S,3S,4S, i = 1,2,.., n_{sc}; s = 2,..,5) \tag{3}$$

$$\sum_{j=1}^{n} R_{ij}^{norm} + d_{is}^{-} \ge t_{i(s-1)}^{-} \quad and \quad \sum_{j=1}^{n} R_{ij}^{norm} \ge t_{i5}^{-}, (for\ all\ i\ in\ classes\ \ 2S,3S,4S, i = 1,2,.., n_{sc}; s = 2,..,5) \tag{4}$$

$$B \ge \sum_{j=1}^{n} c_j x_j \tag{5}$$

where, c_j is the achievement level of performance metric j and $c_j x x_j$ represents the budget allocation to the performance metric j, B is the maximum available budget (=19000 in our illustrative example).

$$d_{is}^{+} \ge 0; d_{is}^{-} \ge 0 \tag{6}$$

$$0 \le x_j \le 1 \tag{7}$$

Apart from the goal constraints mentioned above, we consider the following system constraints also in our methodology:

$$x_{potentiality} \le 0.85 \tag{8}$$

$$x_{\text{Re}\,sourceUtilization} \le 0.8 \tag{9}$$

$$\sum_{j} R_{Ontime\ \ Delivery\ \ Ratio,j}^{norm} x_j \ge 0.65 \tag{10}$$

Using equation (1), the relationships between performance metrics and enablers are normalized and the normalized scores form the body of the HOQ. Table 1 shows the HOQ for the performance measurement. For simplicity, the roof has been removed after normalizing R_{ij} .

Table 1. House of Quality for Performance Measurement

PM	Reputation	I&I	PP	RES	FP	DR	RU	C/Oh	MLT					
Enablers										t_1	t_2	t_3	t_4	t_5
On-time Delivery Ratio	0.138	0.091	0.087	0.093	0.134	0.114	0.12	0.106	0.114	100	80	75	65	50
Returning Customers Ratio	0.142	0.092	0.097	0.091	0.131	0.101	0.116	0.881	0.111	100	90	80	75	65
Green Image	0.117	0.093	0.096	0.084	0.112	0.102	0.098	0.098	0.113	0	1200	1500	2000	2500
R&D Expenses Ratio	0.128	0.075	0.091	0.078	0.12	0.101	0.102	0.093	0.102	50	45	40	35	30
										60	65	75	80	100
New Products/Processes	0.122	0.078	0.09	0.085	0.109	0.095	0.102	0.082	0.098	20	15	10	8	5
										25	30	35	40	45
Flexibility	0.128	0.091	0.092	0.085	0.105	0.106	0.1	0.083	0.098	65	55	50	40	35
After Sales Service Efficiency	0.122	0.083	0.08	0.088	0.109	0.106	0.096	0.104	0.095	100	85	75	60	50
Markets Targeted	0.128	0.083	0.075	0.0884	0.115	0.109	0.1	0.102	0.096	100	80	75	60	55
TP*DT	0.13	0.087	0.078	0.082	0.126	0.104	0.116	0.1	0.181	100	90	80	75	65
TP/SU	0.135	0.084	0.08	0.08	0.126	0.109	0.116	0.102	0.11	100	95	85	70	65
QO-QI	0.124	0.087	0.078	0.079	0.12	0.104	0.111	0.1	0.111	65	60	50	45	40
Effectiveness of MPS	0.135	0.088	0.075	0.083	0.131	0.102	0.115	0.102	0.107	100	85	75	70	65
Facility Location	0.125	0.076	0.079	0.078	0.126	0.102	0.108	0.088	0.102	35	30	25	20	15
										20	25	35	40	50
Labor Cost	0.125	0.09	0.082	0.079	0.121	0.108	0.113	0.094	0.112	20	25	35	40	50
Usage of Automated DA Systems	0.13	0.094	0.078	0.081	0.124	0.103	0.112	0.097	0.105	1000	750	600	500	250
										2000	2500	3500	4000	5000
Cost Index	4000	2500	2000	2500	2500	3000	2000	2000	2000					

Table 2 shows the normalized LPP weights of the enablers (1S, 2S, 4S represent the LPP classes the enablers were classified into) obtained using the algorithm presented in [6].

Table 2. Normalized LPP Weights of Enablers

Enablers	Weights			
On-time Delivery Ratio (2S)	$\tilde{w}^{-}_{12}$ =0.000068	$\tilde{w}^{-}_{13}$ =0.00414	$\tilde{w}^{-}_{14}$ =0.028	$\tilde{w}^{-}_{15}$ =0.967
Returning Customers Ratio (2S)	$\tilde{w}^{-}_{22}$ =0.000224	$\tilde{w}^{-}_{23}$ =0.0034	$\tilde{w}^{-}_{24}$ =0.034	$\tilde{w}^{-}_{25}$ =0.956
Green Image (1S)	$\tilde{w}^{+}_{32}$ =0.000114	$\tilde{w}^{+}_{33}$ =0.006	$\tilde{w}^{+}_{34}$ =0.05	$\tilde{w}^{+}_{35}$ =0.93
R&D Expenses Ratio (4S)	$\tilde{w}^{-}_{42}$ =0.0002	$\tilde{w}^{-}_{43}$ =0.003	$\tilde{w}^{-}_{44}$ =0.06	$\tilde{w}^{-}_{45}$ =0.93
	$\tilde{w}^{+}_{42}$ =0.001	$\tilde{w}^{+}_{43}$ =0.0073	$\tilde{w}^{+}_{44}$ =0.251	$\tilde{w}^{+}_{45}$ =0.74
New Products/Processes (4S)	$\tilde{w}^{-}_{52}$ =0.00016	$\tilde{w}^{-}_{53}$ =0.0023	$\tilde{w}^{-}_{54}$ =0.094	$\tilde{w}^{-}_{55}$ =0.9
	$\tilde{w}^{+}_{52}$ =0.00027	$\tilde{w}^{+}_{53}$ =0.0034	$\tilde{w}^{+}_{54}$ =0.06	$\tilde{w}^{+}_{55}$ =0.935
Flexibility (2S)	$\tilde{w}^{-}_{62}$ = 0.00041	$\tilde{w}^{-}_{63}$ =0.0122	$\tilde{w}^{-}_{64}$ =0.084	$\tilde{w}^{-}_{65}$ =0.902
After Sales Service Efficiency (2S)	$\tilde{w}^{-}_{72}$ =0.000183	$\tilde{w}^{-}_{73}$ =0.0043	$\tilde{w}^{-}_{74}$ =0.039	$\tilde{w}^{-}_{75}$ =0.956

Markets Targeted (2S)	$\tilde{w}^{-}_{82}$ =0.00006	$\tilde{w}^{-}_{83}$ =0.00414	$\tilde{w}^{-}_{84}$ =0.0174	$\tilde{w}^{-}_{85}$ =0.97
TP*DT (2S)	$\tilde{w}^{-}_{92}$ =0.000274	$\tilde{w}^{-}_{93}$ =0.0039	$\tilde{w}^{-}_{94}$ =0.125	$\tilde{w}^{-}_{95}$ =0.87
TP/SU (2S)	$\tilde{w}^{-}_{102}$ =0.00028	$\tilde{w}^{-}_{103}$ =0.0018	$\tilde{w}^{-}_{104}$ =0.019	$\tilde{w}^{-}_{105}$ =0.97
QO-QI (2S)	$\tilde{w}^{-}_{112}$ =0.00028	$\tilde{w}^{-}_{113}$ =0.0018	$\tilde{w}^{-}_{114}$ =0.06	$\tilde{w}^{-}_{115}$ =0.935
Effectiveness of MPS (2S)	$\tilde{w}^{-}_{122}$ =0.00009	$\tilde{w}^{-}_{123}$ =0.002	$\tilde{w}^{-}_{124}$ =0.06	$\tilde{w}^{-}_{125}$ =0.935
Facility Location (4S)	$\tilde{w}^{-}_{132}$ =0.000274	$\tilde{w}^{-}_{133}$ =0.0039	$\tilde{w}^{-}_{134}$ =0.06	$\tilde{w}^{-}_{135}$ =0.93
	$\tilde{w}^{+}_{132}$ =0.00054	$\tilde{w}^{+}_{133}$ =0.0036	$\tilde{w}^{+}_{134}$ =0.125	$\tilde{w}^{+}_{135}$ =0.87
Labor Cost per hour (1S)	$\tilde{w}^{+}_{142}$ =0.0006	$\tilde{w}^{+}_{143}$ =0.006	$\tilde{w}^{+}_{144}$ =0.05	$\tilde{w}^{+}_{145}$ =0.94
Usage of Automated DA Systems (4S)	$\tilde{w}^{-}_{152}$ =0.0002	$\tilde{w}^{-}_{153}$ =0.006	$\tilde{w}^{-}_{154}$ =0.155	$\tilde{w}^{-}_{155}$ 0.83
	$\tilde{w}^{+}_{152}$ =0.0005	$\tilde{w}^{+}_{153}$ =0.003	$\tilde{w}^{+}_{154}$ =0.125	$\tilde{w}^{+}_{155}$ =0.87

The model is solved using LINGO 8, tables 3 and 4 shows the results. Table 3 shows the budget allocation and the achievement levels of performance metrics and Table 4 shows the satisfaction levels of the enablers ($=\sum_j R_{ij}^{norm} x_j$).

Table 3. Budget Allocation and Achievement Levels of Performance Metrics

	Reputation	I&I	Public Participation	Responsiveness	Facility Potentiality	Delivery Reliability	Resource Utilization	Cost/Op.hr	Manufacturing Lead Time
Budget Allocation	1272	2500	2000	2500	2125	2700	1600	2000	1520
Achievement Level (x_i)	0.318	1.0	1.0	1.0	0.85	0.9	0.8	1.0	0.76

Table 4. Enabler satisfaction Levels

Enabler	Satisfaction Level (%)
On-time Delivery Ratio	82.21
Returning Customers Ratio	82.18
Green Image	77.27
R&D Expenses Ratio	72.84
New Products/Processes	73.35
Flexibility	73.74
After Sales Service Efficiency	73.07
Markets Targeted	72.41
TP*DT	81.82
TP/SU	76.42
QO-QI	76.53
Effectiveness of MPS	76.73
Facility Location	74.49
Labor Cost per hour	76.20
Usage of Automated DA Systems	74.28

CONCLUSIONS

Traditionally, performance measurement is defined as the process of quantifying the effectiveness and efficiency of action. Developing the performance measurement systems is a difficult aspect of performance measure selection. Due to the inherent differences in various aspects between the forward

and the reverse supply chains, the performance metrics and evaluation techniques used in traditional supply chain cannot be extended to the reverse supply chains. Customer satisfaction is an indication of the standard level of service, however, for different industries, customers look at different measures. Thus, the weighting of each performance measurement is industry specific. To this end, in this chapter, we identified some of the important performance metrics and their enablers in a reverse/closed-loop supply chain environment and employed a linear physical programming based quality function deployment optimization approach to evaluate a reverse/closed-loop supply chain for its performance.

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ASSESSING THE EFFECT OF PROJECT MANAGEMENT METHODOLOGIES: A WORK IN PROGRESS

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ABSTRACT

Organizations increasingly use projects to achieve business objectives. However, project outcomes are frequently unsatisfactory. In response, standards, such as the Project Management Body of Knowledge, have been developed to reflect what are considered "best practices" in the field. This research focuses on developing a measure to capture the extent to which project management methodologies are implemented, beyond just the planning phase. This measure will then be used to examine the relationship between use of project management standards and project success. A survey has been developed and distributed to gather the data needed to do this.

INTRODUCTION

Over the past decade projects have been increasingly used in organizations to achieve business objectives. Although the use of project management originated in the aerospace and defense industries, its use has spread to diverse business applications such as new product development, organizational restructuring, process improvement, and information technology implementation. In addition, project management is not limited to the private sector; it is being used increasingly by non-profit organizations as well.

Research Motivation

However, successful project outcomes are often elusive. In 2005 KPMG conducted a global IT project management survey of 600 companies in 22 countries [5]. They observed that, although project results may be marginally better than in the past, there is still substantial room for improvement. For example, 86% of respondents reported IT project outcomes that "fell short of planned expectations". To improve the chances of success with such projects, Project Management has emerged as an important discipline in organizations.

Given the increased interest in project management and the desire to improve project outcomes, standards have been developed reflecting what are considered "best practices" in the field. One such set of standards, developed and disseminated by the Project Management Institute, is the *Project Management Body of Knowledge* (PMBOK) [9], which encompasses 5 project phases (including initiating, planning, executing, monitoring and controlling, and closing a project) and 9 project management knowledge areas (integration, scope, time, cost, quality, human resources, communication, risk, and procurement). Another set of standards has been developed by the Centre for Research in the Management of Projects, which became the basis for the *Association for Project Management's* (APM) *Body of Knowledge* [7].

The usefulness of project management rests on the assumption that such PM standards will actually enhance the probability of success. This hypothesis has become more relevant given the increasing use of projects, and the increased size and cost of projects. This is evident in the results from the KPMG 2005 global Project Management survey, where project complexity increased in 88% of organizations and budgets increased in 79% of organizations [5]. Accordingly, organizations more frequently mandate formal methods for project planning, coordination, communication, and control that are commonly based on these standards. However, organizations may face challenges in encouraging the adoption and implementation of these methodologies by project teams if their usefulness is not clear.

Literature Review

Despite the obvious importance, there has been little done empirically to validate this assumption, and the studies that have been conducted have had conflicting results. Without validation of the assumption, the usefulness of project standards will be questioned and motivations to apply them by project teams will be discounted. One research group developed the project management planning quality index (PMPQ) to evaluate project planning and then used it to examine the relationship to project success [3] [10]. Although they found that a higher quality score was positively correlated with project success, their research has been limited to just the planning aspect of project management. Gowan and Mathieu [4] examined the relationship between project management methodology and meeting the target date for completion, but their measure of the methodology was limited to just five aspects of project management. Milosevic and Patanakul [6] examined organizational project management methods and observed that greater standardization of project management tools across projects within an organization was associated with enhanced project management success. Crawford [1] examined the relationships between management's ratings on project personnel in terms of their value and effectiveness and (1) adherence to project management practices and (2) project management knowledge. She observed no significant relationship between either aspect of project management and management's ratings.

The inconsistent and mixed findings in the existing research on the linkage between use of such methods and enhanced project outcomes are the motivation of this paper. Its specific purpose is to examine the variation in project methods that are used in organizations and whether the use of formal project methods enhances project outcomes. Without such a linkage, the usefulness of project management methods will be questioned and motivations to apply them will be discounted. The research constructs and relationships considered in this research, namely project standards and outcomes, derive from a larger research framework representing a complex organizational context in which projects take place [2].

CURRENT RESEARCH PROJECT

There are two phases to the current research project: (1) develop an instrument to assess the use of project management methods and (2) examine the relationship between use of such methods and project success. In addition, we will examine characteristics of projects, such as project size and project focus, to determine if they are related to project management methods and/or success.

Measuring Project Management Methods

The first phase of this research project is to develop an instrument to assess the use of project management methods. Although prior studies have attempted to capture project management methods, the measure of such methods has varied with each study. Gowan and Mathieu [4], in examining large-scale enterprise-wide system upgrades, captured methodology as problem identification, risk assessment, cost calculations, compliance planning, and testing and verification. Zwikael and Globerson [10] used sixteen planning products that reflected the nine knowledge areas in *PMBOK*. Although several of the products are specific (e.g., work breakdown structure, PERT or Gantt chart, activity duration estimates) a number of the knowledge areas are represented by only the associated plan (e.g., quality management plan, communications management plan, risk management plan).

We designed our instrument based on the *PMBOK* by identifying critical processes in project management and the outcome or deliverable associated with each of these, which is the basis for Likert-scale items. This work builds on the work of Zwikael and Globerson [10] by utilizing the aspects of planning included in their project management planning quality index (PMPQ). However, aspects of project execution and monitoring and controlling have been added to provide a more comprehensive assessment of the use of project management methods.

Given this comprehensive list of items, a pilot group of project management practitioners were asked to indicate (1) the importance of each item to success of projects, as well as (2) which phase of project management (initiation, planning, execution, monitoring and controlling, or closing) each item reflects. Based on six responses, the list of items was reduced to 52 items, which includes the items used by Zwikael and Globerson [10]. These items reflect the Initiation, Planning, Executing, and Monitoring and Controlling phases as well as all 9 knowledge areas. One observation based on these results is that respondents accurately and consistently identified items associated with planning but were less consistent and accurate for items pertaining to executing and monitoring and controlling.

Examining the Methods and Success Relationship

A survey was compiled using the revised list of items to capture project management methods, a measure of project success, and questions about project characteristics (project size and focus). The measure of project success will follow the lead in the literature and include aspects of project success (e.g., schedule and budget) as well as product success (e.g., end-user satisfaction) [8]. A large regional Project Management Institute chapter is supporting this research by allowing distribution of the survey via the Web to approximately 1500 respondents. Although we are most interested in Information Technology projects, in this phase we are including multiple project domains in order to evaluate the effect of type of project in the analysis.

The analysis will include Cronbach alpha to assess reliability as well as exploratory factor analysis to address validity of the project management method items and the project success measure. Using Cronbach alpha for the project management method items will allow us to identify additional items that can be removed from the measure to make it as parsimonious as possible. In addition to examining the measurement properties of the measures, the relationship between project management methods and project success will be examined via path analysis

and partial least square (PLS) analysis. Finally, tests will be done to look for effects of other variables including project size, project focus, and industry.

The potential contributions of this research include identifying the most critical components of project management methodologies, providing empirical support for the deployment of such methods, and gaining a richer understanding of the relationships between the methods and project outcomes.

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A PROPOSED METHODOLOGY FOR ENSURING DATA VALIDITY FOR FORECASTING DETAIL PARTS REQUIREMENTS FOR OVERHAULS AND REPAIRS

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ABSTRACT

This paper is a follow-up to a paper that was published by the authors in the proceedings of the 2005 meeting. That paper, titled "Data Retrieval Problems Can Distort Forecasting", showed how problems in retrieving data distorted the forecast for detail parts requirements needed for repairs at Arkwin Industries, Inc. Reviewers praised the paper for solving the problem and for being a possible teaching tool. However, their principal criticism was that it did not break new ground. It was suggested that the paper could be improved by establishing a methodology for "cleaning up" the data, which could be used by companies with similar operations. This paper proposes such a methodology.

REVIEW OF THE PROBLEM

The paper originally began as a paper by one of the authors for a course in the EMBA program at SJCNY. He is employed in the Customer Support Operations Department of Arkwin Industries, Inc. This department repairs and overhauls the hydraulic equipment and fuel control devices that the company manufactures for the aerospace industry. Some of these are warranty repairs. However the majority of these repairs and overhauls are designed to extend the serviceable life of the units. This service is a rich source of profits for the company.

The standard for the industry is a thirty day turn-around-time when servicing components. Unfortunately, approximately 60% of these repairs and overhauls were delayed due to chronic shortages of the detail parts necessary for these repairs and overhauls [5].

The original intent of the paper was to use statistical techniques to forecast detail parts requirements for these repairs and reduce the percentage of delinquent repairs. However, attempts to use statistical techniques were thwarted by problems with the detail parts usage report generated by the company's mainframe computer. The principal problem was that in addition to true usage, the report also treated disposal of limited shelf-life items, and, transfers to the company's main stock room as usage. In addition, items that were used to compile overhaul kits were counted when put into the overhaul kits and also when the kit was issued to a technician. This made it appear that the usage for certain items were double what they really were. All of these factors distorted the usage reports and induced us to order more than we really needed for certain items. This situation also caused us to become a supplier of the production

arm of the company by default. When we were incorrectly induced by our system to order additional parts (to replenish parts transferred to the production section's stockroom) they began to accumulate. When the production stockroom was again confronted with a shortage they requested another transfer to cover their needs. We were again incorrectly induced by the system to order more of these parts. The cycle could have continued indefinitely.

Although the principal problem was having transfers, etc. counted as true usage, we had some items that were counted at a rate less than true usage. This was due to the closing of the repair record before the stock transactions could be entered. They were, therefore, accounted for through the use of stock adjustments. The required method of sorting the report that was used as input for our forecast precluded these being counted as part of the true usage.

THE NEED FOR ACCURACY

The nature of the aerospace industry causes the prices of many of the components that are part of our products to be very expensive. There are three reasons why this is true. First, it is not a mass production industry like the automobile industry, which works with huge production lots. For example, an automobile manufacturer may produce or purchase pistons for their engines in lots that can be hundreds of thousands of pieces. We on the other hand, produce the pistons for our hydraulic units in lots that average fifty. The set-up time for the various machines needed for to produce the pistons in these shorter runs drives up the costs significantly. Second, the industry machining tolerance standards are much more stringent than most industries. Staying within these tolerances makes the production process more expensive. Third, the quality control required by the industry also greatly adds to the expense of each part. This includes not only a small army of inspectors, which is employed by the company; it also includes quality audits and oversight by both government agencies and customers. A small army of administrators and clerks must be employed to handle all of the paperwork that is generated by this oversight.

These three factors drive up the cost of the parts that we purchase as well as the parts that we produce in-house. This makes inventory accuracy a critical factor in keeping expenses down. Small discrepancies for each detail part add up quickly because we must maintain thousands of items in our inventory to support our product line.

COMPARATIVE CALCULATIONS

The following sample calculations reveal how inaccurate our calculations are based on the way our system records and retrieves the data. Each one of these is a real example that was taken from the data stored in our mainframe computer. Each one of these compares the projections made through each analytical method.

FIGURE 1

Single Period Moving Averages [6, pp.237, 238]
Part Number 1211206-282 – Period: 1997 through 2004

(Including Transfers and Adjustments)			(True Usage Only)		
Year	Usage	Moving Avg	Year	Usage	Moving Avg
1997	58	#N/A	1997	58	#N/A
1998	39	48.5	1998	39	48.5

1999	0	19.5	1999	0	19.5
2000	0	0.0	2000	0	0.0
2001	4	2.0	2001	4	2.0
2002	2	3.0	2002	2	3.0
2003	8	5.0	2003	8	5.0
2004	37	22.5	2004	2	5.0

Figure 1 shows this simple method, which averages the current and previous periods' usage. It predicts that we will need to order 23 of this part to cover repairs and overhauls for the next period. When you remove stock transfers from the analysis the prediction is for only five. This simple method often lags significantly behind a trend. To more accurately reflect any trend many people use weighted moving averages to adjust, in part, for any trend.

FIGURE 2

Weighted Three Period Moving Average [2, p22]

Part Number 1211206-282 – Period: 1997 through 2004

Weighting Factors: 1st period = .2: 2nd period = .3: 3rd Period = .5

Period	Usage	Weighted Avg	Period	Usage	Weighted Avg
1997	58	#N/A	1997	58	#N/A
1998	39	#N/A	1998	39	#N/A
1999	0	23.3	1999	0	23.3
2000	0	7.8	2000	0	7.8
2001	4	2	2001	4	2
2002	2	2.2	2002	2	2.2
2003	8	5.4	2003	8	5.4
2004	37	21.3	2004	2	3.8

Figure 2 makes it easy to see that the weighting factors help reduce the lag behind the trend that is noted in the table above. The results, however, are still distorted by the inclusion of transfers and adjustments. The method predicts that we should order twenty-two of these parts. When you remove the transfers and adjustments, the true usage calculation predicts a requirement of four, which is much lower as in the single period, unweighted moving above.

FIGURE 3

Exponential Smoothing with Trend Projection [4, pp.155-157]

Part Number 1211285-105-2 Period: August 1, 1997 through July 31, 2005

With Transfers and Adjustments

Period	Reported Usage	Exponentially Smoothed Forecast	Smoothed Trend	Trend Adjusted Forecast
8/1/97 - 7/31/98	18	#N/A		
8/1/98 - 7/31/99	16	18.0		
8/1/99 - 7/31/00	52	16.8		
8/1/00 - 7/31/01	40	37.9		

8/1/01 - 7/31/02	5	39.2	17.1	56.3
8/1/02 - 7/31/03	3	18.7	-3.1	15.6
8/1/03 - 7/31/04	38	9.3	-18.3	-9.0
8/1/04 - 7/31/05	18	26.5	-4.1	22.4
		21.4	12.8	34.2

FIGURE4

Without Transfers and Adjustments

Period	Actual Usage	Exponentially Smoothed Forecast	Smoothed Trend	Trend Adjusted Forecast
8/1/97 - 7/31/98	18	#N/A		
8/1/98 - 7/31/99	16	18.0		
8/1/99 - 7/31/00	52	16.8		
8/1/00 - 7/31/01	15	37.9		
8/1/01 - 7/31/02	5	24.2	14.1	38.3
8/1/02 - 7/31/03	3	12.7	-13.3	-0.6
8/1/03 - 7/31/04	6	6.9	-10.4	-3.5
8/1/04 - 7/31/05	3	6.3	-4.7	1.6
		4.3	-0.8	3.5

The purpose of exponential smoothing with trend adjustment is to provide a superior predicting tool where trends may be involved. This reduces the lag behind trends that was noticed in analyses above. Unfortunately, the false trend that is indicated in figure 3 for the period from August 1, 2003 through July 31, 2005 incorrectly inflates the prediction for the period, indicating that we should order 34. The analysis in figure 4 reflects the true usage data and indicates that we should order only four of this part for the coming period.

All of the preceding methods are valid tools for predicting future period requirements for our repairs and overhauls. However, every one of them provides predictions that are very inaccurate when made with the inclusions of transfers and adjustments. There are, in fact, some items that we have not used in repairs or overhauls for many years, but transfers of these parts to the production stockroom give us a false report of usage. This often induces us to order parts that we truly do not need. When you multiply the number of excess parts that the system induces us to order by the high cost of the parts, it is easy to understand how our inventory became so bloated over time, despite the many shortages of critical parts. The underreporting of other parts only offsets this fractionally.

SOLUTIONS TO THE PROBLEMS

After uncovering these problems we met with the person in charge of the Information Services Department and outlined the problems for him. He was able to provide us with an option to exclude transfers of stock within the company from the reports that the mainframe generated. The following month I printed the report that is used to order parts. I printed it in the old format, which includes transfers in the usage field. I then printed it in the new format, which filters out the transfers and compared it to the old format. This comparison revealed that ordering parts based on the new format would save us at least $36,000 in unnecessary orders for the month that the reports were printed In addition; we estimate that we will save approximately $250,000 during this year [5].

We have been much less successful in solving the other data problems, which include reporting stock adjustments as usage when the stock was disposed due to age, and closing repair/overhaul records before parts usage can be recorded. The Information Services Department has had great difficulty adjusting the reports for these problems. We are now exploring the possibility of taking our inventory system off the mainframe and putting it on a separate server. We will then be able to employ software that will allow us to eliminate all of the remaining problems.

The Proposed Methodology

Step 1 – Determine Inventory Forecast Accuracy

At this point many readers may already be aware that their forecasts have been inaccurate due to data collection or retrieval problems. However, others may not be sure whether they have a problem or not. There are ways that can be used to determine the extent of the problem, if one exists. First, simple observation should be employed to see if inventory levels are rising out of proportion to the demand for repairs and overhauls. This may indicate that the forecast is being skewed by items that should not be part of the data that is used to develop your forecast, or that some items are being double counted. Both of these possibilities were mentioned above. The percentage increase of inventory levels should be proportional to the growth of repair and overhaul sales. This can be done in the aggregate, matching the overall sales growth against inventory levels. This method may, however, mask the disproportionate growth of certain items. It will probably be more advantageous to check inventory for certain detail parts instead. The ABC inventory classification method is discussed below to help guide the choice of items to check.

Second, records should be checked to determine if the frequency of stockouts (those items that are not available when needed) for components is unacceptably high or increasing despite the on-time arrival of forecasted items. This may indicate that some items are missing from the data used to develop the forecast. This problem was also mentioned above. Two ways to check this possibility are discussed below.

Checking the Items That Will Produce the Best Results

In the case of rising inventory levels, which are out of proportion to sales of repairs and overhauls, an analysis using the ABC method can be done to reveal those items that have the greatest potential effect on inventory costs. This analysis is based on the work of Italian economist Vilfredo Pareto. According to Pareto analysis 20% of inventory items will account for about 80% of the cost of inventory. These are the category A items. Category B items account for about 30% of inventory items and 15% of total inventory cost. Category C items make up the remaining 50% of inventory items but only 5% of total inventory costs [1, p245]. To highlight this, consider that many of Arkwin's products have bills of materials that have more than 100 pieces. This includes numerous "O" rings, seals and screws. Most of these items will range from as little as $.08 to $10.00. The vast majority of these are C items that cost less than

one dollar. The Housing, Piston, Electronic Components and End Cap together will cost more than $500.00 and be approximately 80% of the cost.
The benefit of using the A items as the starting point where inventory levels are rising out of proportion is that you will only need to review 20% of inventory items. This narrow focus saves time, but can produce results in two ways. First, finding and correcting problems connected with the higher cost items will give the highest possible dollar savings. Second, many of the data problems associated with these items may also be associated with the lower cost items. When you fix whatever problems are occurring with the data collection and retrieval for the A items, the B and C items will be corrected automatically if the same problems are occurring for them as well.

In the case of frequent stockouts two options exist. First, check the items that are most frequently out of stock. This is the easiest way and will likely produce good results. It may, however, simply be a case of showing you the items that are out of stock due to growth in the demand for repair/overhaul of the top assembly that it is used in. This probably means that you are not accounting for the growth trend in your forecast and is not as likely to be a problem with the data collection and retrieval. The second option is to compare the frequency of stockouts for a given component to the growth in sales of repairs/overhauls for the top assembly using the following equation:

Equation 1

$$\frac{\text{Frequency of stock-outs for inventory item}}{\text{Growth in repair/overhaul of top assembly}}$$

For example, if an item is out of stock 10 times in a period while the growth of overhauls grew by 75 units (top assemblies) in that period the result would be .13. However, if an item was out of stock 10 times when overhauls and repairs increased by 30 units the result would be .33. Since the second example has a higher ratio it may indicate that there is a problem other than explosive growth causing the stock-out condition. It may indicate that something is missing from the data that is used for forecasting and provide a good point for starting your search for the problem.

Caution must be employed here to ensure that the increase in the number of stock-outs is not a result of overzealous technicians declaring detail parts to be scrap when they are still serviceable. At Arkwin some technicians were disposing of detail parts that simply needed to be cleaned or polished to keep them within the acceptable specifications for that part. Technicians cannot scrap category "A" inventory without supervisory review.

Step 2 – Specifically Define What You Intend to Measure or Analyze

It is impossible to ensure data validity and reliability until you specifically define what you intend to analyze and what the goal(s) of the analysis are. Without knowing these two things you cannot know the precise recipe of data that will produce the analysis you desire. In the Arkwin case we were trying to specifically measure only the quantity of each detail part that was used for repair or overhaul for each recent historical period. We then intended to use each period's usage data to forecast the need for future periods. A key goal of this analysis was to identify trends in usage. This would enable us to increase stock in anticipation of future demand for certain parts and to avoid overstocking those items that had a downward usage trend. In defining what you

intend to analyze and the goals of the analysis it may be helpful to put the definition in the form of a statement that everyone involved in the project can understand. For Arkwin's situation it may be: "We desire to measure the usage of detail parts for repair and overhauls only for each year for the five most recent years. We then intend to use this data to forecast the required inventory for each detail part for each of the next three years with a special effort toward determining trends in the need for each part."

Step 3 – Specifically Define the Data Needed for the Analysis and Eliminate the Data That Does Not Fit the Definition

Once the specific goals of the analysis are known it is then possible to specifically define the data that should be in the analysis. The next sub-step is to search through the data that will be used in your analysis to find and eliminate those items that do not fit the definition and eliminate them from the analysis. In the Arkwin case the data was compiled into a usage report that was supposed to give us the total usage of each inventory item for repairs and overhauls in a given period. However, when we checked the stockroom transactions for certain items against the usage report it was immediately evident that other items such as transfers to the production stockroom were included in the totals for each detail part. Since these items do not fit the definition they skewed the results of our analysis. Our Information Services Department was then able to give us the ability to print the report without the inclusion of these transfers. It will be necessary to work with the I.S. Department of your company to 1) determine what data is fed into your analysis, 2) find the data does not fit the definition of what should be included, and, 3) eliminate the nonconforming data.

Step 4 – Ensure That All the Data That Fits the Definition in Step 3 is Included in the Analysis

Once all of the nonconforming data has been eliminated it is necessary to verify that all of the appropriate data is included. This may be more difficult since it is easier to find what does not belong rather than to notice what is missing. It may be necessary to check all the stockroom transactions for certain items against the total reported usage for a part. If the total of all the data that should be in the analysis is more than that which is being fed into the analysis some of the data is being omitted. The comparison of increases in stockouts with the growth of repairs/overhauls for the each top assembly that was discussed above can be used to guide your inquiry. In the Arkwin case the computer would not allow any stockroom transaction to be entered for any repair record that had already been shipped to the customer. This forced the stockroom personnel to enter these as stock adjustments and cite the repair order number as the reference. These items were not counted as true usage. These were very few items and we have not yet remedied this situation. However, it serves as an example of what is possible and may be more of a problem in another company.

Step 5 – Verify and Maintain Forecast Accuracy

After all of the preceding steps have been accomplished the forecast should be verified for accuracy. This can be done by using the data for all of the past periods to forecast the demand for the most recent period for which data is available. If the forecast is still inaccurate two things must be examined. First, since you have gone through all of the previous exercises it might be that your data is reasonably accurate, but your forecast method is not identifying trends quickly enough. The best way to check forecast accuracy is to calculate the tracking signal for the

forecast. The formula for the tracking signal is: Running Sum of Forecast Errors / Mean Average Deviation. The mean average deviation is the sum of all deviations without regard to whether they are positive or negative divided by the number of occurrences. The running sum of forecast errors is the sum of all forecast errors tallies the errors taking into account the positive and negative signs for each period's error. For some items a tracking signal of +/-6 is acceptable [7, p369]. However, higher cost items may require a lower tracking signal [7].
It must be noted that there may still be errors in the collection and retrieval methods and it may be necessary to go through the methodology again.

Notes for Applying the Methodology

- Each firm is different and has different computer systems, operating procedures, and organizational structure. These and other factors can influence the decision of what to include and exclude from the forecast data. At Arkwin we sell detail parts to customers that repair and overhaul their own units. These are shipped from our production stockroom and have no effect on our analysis. Other firms, however, ship detail parts from their repair stock and must be included in the analysis, since both can influence trends.
- The accuracy of the forecast should be checked for each period that a forecast is made and any necessary changes should be made to restore forecast accuracy
- The Information Services Department should be involved as early in the process as possible. Their knowledge of how the data is collected, stored, and retrieved can be extremely valuable in finding potential problems.
- The Information Services Department may not understand how your operation works and what each data item truly represents. Their expertise is the computer system. Therefore, you must work with them to help them understand your operation and how the data relates to your operation.
- Employees that have experience in the department and understand how each kind of data relates to each other should be included in your team as early in the process as possible. This will help speed up the process and add valuable input.

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Appendix – Process Map

Step 1 – Determine forecast accuracy

- Observe relationship between growth of repairs/overhauls and the growth of inventory levels.
  - Can be aggregate or individual inventory item.
  - Use ABC inventory classification to guide your inquiry for choice of individual items.
  - If disparity exists between the growths of repairs/overhauls and the growth of inventory a data problem may exits.
- Observe frequency of stockouts. – If they are increasing despite the on-time arrival of detail parts orders a data problem may exist.
  - Check most frequent stockout items to see if data is missing from the analysis.
  - Use a ratio of Frequency of stockouts for an inventory / Growth in repairs/overhauls of top assembly

Step 2 - Specifically define what you want to analyze and what the goal of the analysis is.

- Definition must be clear and specific
- Goal(s) must be clear and understandable.
- Put in statement form

Step 3A – Specifically define the data that is needed for the analysis that is defined in step 2.

Step 3B – Search through the data to find the data that do not conform to the definition and eliminate the data that does not conform to the definition

Step 4 – Ensure that all the data that fits the definition in step 3 is included.

- Search through all data, including all stockroom transactions and ensure that all the conforming data are included.
  - If the total is more than that which is being fed into the analysis some of the conforming data is being omitted.
  - Categorize each of the conforming data.
    - Count the data in each category.
    - Determine which categories are missing

Step 5 – Verify and maintain forecast

- The accuracy of the forecast must be measured to verify that reliable results are being obtained.
- A tracking signal should be developed for the aggregate forecast and for key inventory items.
  - Tracking Signal = Running sum of forecast errors / Mean average deviation.
  - Any tracking signal +/- 6 indicates that the forecast needs to be reviewed.
  - For category A items a lower tracking signal may be needed due to the high cost of the material.

DETERMINANTS OF GROCERY STORE SALES: A MULTIPLE REGRESSION APPROACH

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ABSTRACT

Grocery store sales forecasting can be one of the most difficult jobs a store manager must do each month. Store sales vary week to week for many reasons including changes in the general price index, economic growth, purchasing power of the local population, seasonal effects, weather, etc. Typical methods to forecast sales use exponential smoothing or use regression models to forecast sales by the recent historic trend. Such models are relatively easy to employ but are quite naive in capturing all of the factors affecting sales. A large grocery store chain needs to incorporate specific information relating to each store's particular demographic makeup to obtain a more accurate forecast rather than a simple trend approach. In this study, sales are forecasted for a grocery store in a low-income area to highlight the need of using customized forecasts for each grocery store in the chain. Controlling for activation days on government food purchasing cards, used by many of the patrons of this store, greatly enhances the forecast. Using backward stepwise regression and dummy variables to control for these activation days, in addition to the traditional factors affecting sales, produced a much more accurate forecasting model.

INTRODUCTION

Whether a business provides goods or services, forecasting sales accurately is a vital function for any company. It is the foundation of how a company will plan and perform daily operations. Many companies fail to realize the importance of this management function, which is a key contributor to a company's success. "Excellence in sales forecasting can boost a firm's financial health and gratify customers and employees alike." [4, p.44]

Without a good sales forecast a company is seriously handicapped in planning its production, planning its purchasing, scheduling its inventory adjustments, setting sales quotas, budgeting expense, and, in general, doing the sort of planning, scheduling, and controlling which are vital to making as much profit as possible under competitive conditions [2]. Through observation, Richard C. Wiser (Vice President, Financial Planning and Analysis, Mary Kay Cosmetics) and his colleagues discovered that management sometimes does not understand statistical forecasting methods [5].

The purpose of this paper is to compare the current sales forecasting methodology of a nationwide grocery store chain, which uses a naive trend approach, obtained from a

nationally known forecasting vendor, to sales forecasts from a flexible multiple regression model based on easily known idiosyncrasies of a particular store. A regression model is developed for each department of a specific grocery store to predict sales in that department using a variety of independent variables (holidays, activation days, local economic conditions, etc.), depending on the department. These forecast results will be compared to the actual forecasts made by the store management through the use their current forecasting software by a mean square error approach using 10 weeks of out of sample data.

Current Forecasting Methodology

Currently the store manager takes two days to forecast sales for all store departments for each of the four weeks in the next month. These sales forecasts are sent to the district manager and then to the corporate home office. The accuracy of the sales forecasts directly impacts the evaluation of the store director, his/her promotion, bonuses, etc., as well as the operating efficiency and profitability of the store. At present, each store manager (several hundred all total) uses his/her own method for making sales forecasts in conjunction with a program provided by the home office. This program, used widely in the industry, simply calculates sales projections by adding the sales trend selected to the previous year's sales. The manager then makes adjustments based on his/her experience, intuition, and professional judgment.

Based on a store manager making $100,000 a year, 260 work days in a year, and two days a month to make forecasts, each manager is being paid approximately $9,230 each year just to make forecasts. If these forecasts are not accurate, much of this money is wasted. The degree to which a store manager understands the various factors that drive his/her store sales will vary with the experience of the manager. Incorrect assumptions about factors which affect sales growth for a particular store could possibly hinder future sales growth for the company as a whole. With an improved forecasting method, store managers can reduce the time they personally spend on forecasting, properly schedule employee work hours, improve order writing, control inventory levels, reduce shrinkage, create efficient store operations, and give better customer service.

DATA

For this study, one grocery store was used as a pilot study to determine if the current method of forecasting should be revised for the entire chain. The particular store was in a low-income neighborhood in a mid-sized city in Texas with predominantly an African-American and Hispanic clientele. It averages several hundred thousand dollars in weekly sales and contains nine typical departments found in most major grocery store chains. Forecasts for the six largest departments (grocery, market, drugs, pharmacy, produce and gasoline) will be included in this paper to help obfuscate the identity of the actual store.

Weekly store sales and departmental sales were collected from the last two fiscal years (FY 2003 & 2004). Since sales at grocery stores are impacted by holidays, special dummy variables were formed for the following holidays: Christmas Eve, Christmas,

New Years Eve, New Years Day, Easter, Cinco De Mayo, Mothers Day, Fathers Day, July 4, Labor day, Ash Wednesday, Valentine's Day, Memorial Day, Thanksgiving, and Spring Break. Each holiday was analyzed as a separate dummy variable for each individual department forecast model to determine which specific holidays had the greatest impact on sales. For some departments, the individual day was very significant. For instance, Mothers Day and Valentine's day were the primary determinants for explaining variability in floral sales (results not shown in this paper). However, such holidays were not individually statistically significant in explaining grocery or market sales. Therefore, for most of the departments, holidays were also grouped together as either "special days but open" or "special days but closed."

The weekly average price for all grades of gasoline was used as an independent variable for the gasoline department. A variety of economic data was obtained to capture changes in the local economy. However, the size of the labor force, unemployment, interest rates, and population growth were little changed over the two years studied and had little statistical significance and were thus dropped from the models.

"Activation days" are the days of every month when customers who receive government assistance receive their monthly balances on Lone Star cards, used for food purchases only, and social security checks. These days include the 1st, 3rd, 5th, 6th, 7th, 9th, 11th, 12th, 13th, and 15th of every month. This type of media was found to have an enormous impact on store sales, especially stores with low-income clientele.

METHODOLOGY

A multiple regression model was formed for each of the six largest departments using the backwards stepwise approach. The goal of the final model for each department was to explain sales in a straight forward manner so that the store manager and home office could accurately interpret the coefficients and the relative impact each independent variable had on store and department sales. With the final model obtained for each department, ten weeks of out-of-sample data was used to compare the new multiple regression sales forecast to the old method sales forecast. The Mean Squared Error (MSE) was computed for the difference of actual sales vs. each of the forecasted values. The degree to which the MSE dropped was used to evaluate the validity of the new forecast method.

RESULTS

Table 1 shows the final model results for each of the six largest departments and the overall store. Each of the data sets used contained 105 weeks of data since 2003 contained 53 weeks for the fiscal year and 2004 contained 52 weeks for the fiscal year. The specific forecast results from the entire store, grocery, and market departments will be discussed in detail with the statistics being shown for all 6 of the separate departments.

Grocery Regression Model

The initial model used to explain "grocery" sales included dummy variables for each of the main holidays, the trend measured by "week", activation days, and moving average. Thanksgiving, New Years day, Superbowl week, and Easter were found to be statistically significant at the .10 level. This model had an R-square of approximately 66%. The inclusion of each holiday as a separate dummy variable stemmed from the results obtained on a small department, "floral" (results not shown) which had an R-square of over 90% due to the extremely strong relationship of Mother's Day and Valentine's Day to flower sales. While separate dummy variables worked extremely well for the floral

TABLE 1

	Grocery	Drugstore	Produce	Market	Pharmacy	Gasoline	Store
R-Square	0.71	0.45	0.71	0.78	0.51	0.49	0.72
Observations	105	105	105	105	105	105	105
Fstatistic	58.7	27.9	81.5	116.5	18.4	48.3	63.1
Intercept	212637	42614	7538	67351	78000	13971	504199
	115.6**	6.26**	3.92**	52.9**	38.5**	3.5**	110.7**
Week	51.54			112.4	133.8		364
	2.05*		624	5.36**	4.7**		5.85**
Activation Days	4967	684	7.33**	4554.7	1717		12521
	12.89**	4.08**		17.01**	3.98**		13.13**
Special Day Closed	-9412					-6396	-34766
	-2.68**					-2.86**	-3.46**
Special Day Open	11728	13373	5446	5424			18241
	5.5**	7.71**	8.7**	3.81**			3.87**
Moving Average		0.28	0.64			0.72	
		2.59*	8.97**			8.97**	

* Significant at .05
** Significant at .01

department, such holidays do not drive sales in the other departments to such an extreme extent. Grouping the holidays together was the logical choice due to each being a factor in sales but as a group they were much more interpretable for the larger departments like grocery and produce.

The model was run again by grouping all of the holidays into two categories- "special days but closed" and "special days but open." Table1 indicates an R-square of 70 percent. Thus 70% of the variability in grocery sales can be attributed to the following independent variables: week, number of activation days in a week, special day but closed, special day but open, and grocery moving average. Base level grocery sales are approximately $212,637 for the period with a slight upward trend of about $51 captured by the "week" variable. After correcting for a slight increase in inflation over the two year period, the "real" grocery sales over the period did not change much-if at all. For

each "activation day", sales in a typical week increased about $4,967. When a week had a holiday but was closed or open sales increased $11,728 and dropped $9,412 respectively. The F-test, overall level of significance, was 47.33. The grocery moving average variable was removed due to its p-value or level of significance of .26641.

A comparison of the actual sales data to the forecast using the old method and the new method is shown in Table 2 through the use of the MSE and the percent difference of the old MSE vs. the MSE using the new method. These results are from using the model developed from the previous two years and then forecasting for the next 10 weeks with out of sample data. The new method reduced the MSE by 55% vs. the old forecasting method.

TABLE 2:

	MSE: OLD FORECAST METHOD	MSE :NEW FORECAST METHOD	% REDUCTION IN MSE
GROCERY	67,583,928	30,230,803	-55%
DRUGSTORE	27,861,526	10,623,930	-62%
PRODUCE	4,951,915	2,522,755	-49%
MARKET	103,678,060	26,957,239	-74%
PHARMACY	246,073,828	135,349,513	-45%
GASOLINE	121,985,762	69,615,048	-43%
STORE	914,480,080	435,779,593	-52%

Market Regression Model

The results for the Market department were the strongest of any department shown in this study with the final model having an R-square of 78% and an F-statistic of 116. Each independent variable had a significant impact on market sales with the exception of "special day but closed" and "market moving average" variables. The base level of market sales was found to be $67,351 with a positive trend of $112 per week-about the same increase as would be expected from a general rise in prices over the period. Variability around the base sales level was primarily due to activation days which accounted for an increase of $4,554 per activation day. Finally, when there was a holiday and the store remained open, sales increased by about $5,424. It is interesting that the market sales, which include mostly meat and poultry, were not statistically affected by holidays where the store closed- as was the case for general grocery sales. Table 2 shows the new model reduced the MSE of the forecast by 74%.

Total Store Model

The store regression model is inclusive of all department sales. An R-square of 71 percent was obtained with an F-statistic of 63. The only variable that had a p-value greater than .05 was "store moving average" at a .399, which indicated that it had the least significant impact and should be removed. The other independent variables had p-values that were less than .05, and had a significant impact on store sales.

The store as a whole had a base level of sales of over $500,000 each week and an upward trend of $364 dollars each week- due primarily to the general increase in prices of consumer goods. For each activation day, sales increased approximately $12,521. When the store closed, sales dropped by almost $35,000 and when there was a special holiday and the store remained open sales increased over $18,000. Table 2 shows that the new forecast model reduced the MSE for total store sales by 52%.

CONCLUSIONS

The statistical models formed using the multiple regression method proved to be much more accurate than those typically employed using simple trend projections. Further, the results highlight the need for upper management to look the idiosyncrasies of each store to build a unique forecasting model for each and not use a generic approach. This study focused on a store in a low income area and it was determined that "activation days" was highly significant. In stores located in more affluent areas, such a variable probably would not be necessary and should be replaced by some other factor. With an improved forecasting method, store managers can properly schedule hours, improve order writing, control inventory levels, reduce shrink, create efficient store operations; consequently, resulting in excellent customer service.

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MITIGATING THE END-OF SHIFT SYNDRONE IN OPERATIONAL SETTINGS

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ABSTRACT

This exploratory study is the first to examine the effects of melatonin supplements in an occupational setting. Using a randomized pretest-posttest design, participations received a daily supplement of melatonin or a placebo for 30 days. Participants receiving melatonin, relative to those receiving the placebo, had improved work-related performance and longer sleep hours. The improvement in sleep hours partially mediated the effects of the melatonin intervention on performance. These effects were stronger in older workers than younger workers.

Keywords: **Fatigue, Occupational Setting, Industrial, Melatonin**

INTRODUCTION

The occupational and health-related literature addresses the effects of physiological and environmental factors on melatonin levels in the human body (e.g. Baskett et al., 2001). Many of these studies focus on the effects of reduced melatonin levels found in electrical workers and others who are routinely exposed to strong Electromagnetic Fields (EMF) (e.g. van Wijngaarden et al., 2000; Tynes et al., 2003). Other studies focus on the effects of reduced melatonin levels in shift workers (e.g. Benhaberou-Brun et al., 1999; Lamond et al., 2003; Zhu et al., 2003). This issue is important because evidence suggests that lower melatonin levels are linked to increases in sleep disorders and depression (which ultimately affect job performance), suicide rates, and cancer rates among workers in these industries (Villeneuve et al., 2000; Lamond et al., 2003). Despite the interest in this area, experiments on the effect of melatonin supplements on worker performance are non-existent in the occupational literature. Effects of melatonin supplements on sleep disorders are only moderately addressed in the health-related literature. Therefore, we reviewed the health-related literature to suggest how and why melatonin supplements may improve worker performance in an occupational setting.

The first experiment of melatonin on human subjects was conducted by Aaron Lerner in1962. He found that the hormone provided a slight sedative effect when applied intravenously (Zhdanova and Wurtman, 1997). First thought to be secreted only by the pineal gland, recent research found that melatonin is also synthesized in other organs such as retinas, bone marrow, and bile (Reiter et al., 2000). Characterized as the 'sleep-promoting' or 'sleep hormone' (e.g. Zhdanova et al., 1997; Rose and Kahan, 2001) melatonin was first shown to regulate the wake-sleep cycles (synchronize circadian rhythms) in humans (Armstrong et al., 1986; Sack et al., 1992; Zhdanova et al., 1997). Melatonin production is activated by the onset of darkness – with increased levels of the hormone in the body associated with high degrees of darkness (Cagnacci, 1996). As light is introduced, the hormone level in the human body radically drops until it becomes negligible. Introduced as a dietary supplement in health food stores, melatonin became a popular treatment to assist shift-workers in regulating their circadian rhythm, or to reduce jet-lag in air travelers who crossed multiple time zones (Dawson et al., 1995; Hughes and Badia, 1997; Edwards et al., 2000). Taking the supplement by mouth prior to bedtime resets the sleep cycle to begin approximately 30 minutes to two hours after ingestion. In most studies, a single dose was sufficient to counteract the disruptive effects of mild sleep disorders (i.e. jet-lag, and the so-called Monday morning blues) (Lewy, 2001; Herxheimer and Petrie, 2001; Yang et al., 2001). Despite numerous articles on the positive effects of melatonin on health, we found no study which tested the hormone in an occupational setting. In other words, the use of melatonin supplements to alleviate common work-related problems, such as end-of-shift fatigue, that could be induced by inadequate sleep.

Despite many reported successes (e.g. Armstrong et al., 1986; Cassone, 1990; Lewy et al., 1992; Attenburrow et al., 1996; Sack et al., 2000; Smits et al., 2003; Wyatt, 2004), the effects of exogenous melatonin administration to correct sleep disorders have been mixed. Some studies show that subjects experienced negative effects of "grogginess and tiredness", upon awaking after melatonin use rather than feeling rested and alert (e.g. Rose and Kahan, 2001). Others experienced modest or no effects of melatonin on sleep quality or circadian rhythms (e.g. Lushington et al., 1997; Dijk et al., 2001; Singer et al., 2003). Still others found the greatest

health benefits are its antioxidant properties for removing toxins from the bloodstream (Gitto et al., 2001). Reasons for these discrepancies have yet to be addressed in the literature; however, after reviewing over 300 scientific articles on melatonin experiments, we find evidence that some of the variance in effects could be explained by variance in dosage size and administration method. However, like dosage size, there is no general agreement on the best way to administer melatonin.

In addition to treating temporary, mild sleep disorders (i.e. jet-lag and insomnia) in otherwise healthy adults, melatonin has been used to treat clinical sleep disorders in children (e.g., Zhdanova et al., 1996; Lin-Dyken and Dyken, 2002), sleep disorders in the aged (e.g. Haimov et al., 1995; Lushington et al., 1997; Hughes et al., 1998; Zhdanova et al., 2001; Baskett et al., 2003), sleep disorders in patients with Alzheimer's disease (e.g. Singer et al., 2003), fatigue in Chronic Fatigue Syndrome patients (e.g. Teitelbaum et al., 2001), toxicity in septic newborns (e.g. Gitto et al., 2001), sleep disorders in chronic whiplash patients (e.g. van Wieringen et al., 2001), seizures in epileptics (e.g. Peled, 2001), Periodic Limb Movement Disorder (PLMD) (e.g. Kunz and Bes, 2001), and circadian synchronization in the blind (e.g. Lockley et al., 1999; Sack et al., 2000). All but two of these applications were for treating sleep deficiencies. Therefore, there is sufficient evidence to suggest that melatonin may improve sleep quality that is diminished by a plethora of disorders.

In the present study, we expected that administration of melatonin would improve worker performance. We expected the effect to be mediated by improvement in sleep hours, which should reduce fatigue-related performance degradation.

METHOD

Participants

Initial baseline data were collected on 366 participants (pre-test sample). Sixty-four participants were excluded (incomplete data) or voluntary dropped out of the study. Post-test measures were collected on 302 participants. After screening the data for univariate and multivariate outliers (Tabachnick & Fidell, 2001; Cohen et al., 2003), 15 participants were excluded. This left a final sample of 287 (M age = 31.87, SD = 13.41; 140 females and 147 males): 119 in the control group (placebo) and 168 in the experimental group (melatonin). Feedback from participants who dropped out of the placebo group indicated that they experienced little or no effect and viewed the intervention as a waste of time.

Study Design

The study design was a placebo-controlled, randomized, double-blind experiment where baseline data were collected prior to administration of the melatonin and after 30 days of continuous melatonin use. Participants received either melatonin or a placebo. Melatonin (or placebo) was administered orally by the participant 30 minutes prior to their normal bedtime. A dosage of 1 mg. of melatonin was chosen by the company physician based on Attenburrow, et. al. (1996) and consultation with several colleagues who suggested a low dose range of .3 to 3 mg. One week's worth of the hormone or placebo (7 tablets) was given to each worker on Monday's. Participants were asked to maintain a daily record of their sleep hours. For the first few days of the study,

plant meetings were held to ensure sleep records were being completed and the hormone/placebo was being administered properly.

Measures

In addition to demographic data, (gender, age, job type), data were collected on, average sleep hours per 24 hour period four weeks prior to and during the 30 day intervention period, and a performance measure assessed just prior to the intervention and again at the end of the 30 day intervention. The measure of pre-intervention sleep was the per-day average over the four week pre-intervention period and the post-intervention measure was the per-day average during the 30 day intervention period.

The performance measure used was based on the company's job analysis. Workers are expected to remember part specifications and new product details and visually detect defects. In order to visually detect defects, workers must remember new product details. The performance measure assessed memory and visual detection of defective parts. The measure included a simple digit span, recall of part specifications after being shown a series of common specifications for 1 minute, and detection of defects after being shown specifications. There were a total of 20 items (worth 5 points each) which summed to total score of 100. In order to minimize carry-over effects from the pre-intervention to the post-intervention assessment of performance, the specific specifications and defects were altered for the second administration. The correlation between the first and second administration 30 days later was .63.

RESULTS

Descriptive statistics for each variable are shown in Table I. Regression-adjusted change (Cohen et al., 2003) in performance was the primary outcome measure. The pre-intervention performance served as a control variable and the experimental manipulation (placebo vs. melatonin, dummy coded) served as the predictor variable.

Table I - Descriptive Statistics

Variable	Mean Placebo/Melatonin	SD P/M
Age	30.82 / 32.61	13.46 / 13.37
Pre-Intervention Performance	71.00 / 68.96	11.58 / 12.42
Post-Intervention Performance	71.30 / 76.90	10.96 / 10.72
Pre-Intervention Sleep Hours	6.73 / 6.13	1.02 / 1.15
Post-Intervention Sleep Hours	7.11 / 7.82	.99 / 1.08

The test of the effect of the melatonin intervention on regression adjusted change in performance was significant, B = 7.03, t(284) = 7.37, with a partial r-square (effect size controlling for pre-

intervention performance) of .16. The performance of workers receiving melatonin improved by over 7 points more than the performance of workers receiving the placebo.

We examined potential moderators of the effect of the melatonin intervention on performance. Neither gender nor job type interacted significantly with the intervention. A small but significant moderating effect of age was found, B = -.21, t(282) = -3.03, p < .005, partial r-square = .03. An analysis of simple slopes indicated that the melatonin intervention improved the performance of older workers more than younger workers. The performance of older workers [mean of age (31.87) plus 1 SD (13.41)] improved as a result of the intervention by almost 10 points (9.81) relative to the placebo group while the performance of younger workers (mean of age minus 1 SD) improved by just over 4 points (4.12) relative to the placebo group.

Next, we tested the hypothesis that the improvement in performance for workers receiving melatonin was mediated by an increase in sleep hours. In other words, some, or all, of the effect of the melatonin intervention on change in performance may be due to an increase in sleep hours as a result of using melatonin. Testing this hypothesis requires testing the effect of the intervention on the change in sleep hours, testing the effect of the intervention on change in performance, and testing the partial effect of the intervention (controlling for change in sleep hours) and the partial effect of the change in sleep hours (controlling for the intervention) on the change in performance (Judd & Kenny, 1981; Sobel, 1982; MacKinnon et al., 2002). The mediating, or indirect, effect is assessed by the difference between the total effect of the intervention on change in performance (change in performance regressed only on the intervention) and the partial effect of the intervention on change of performance (controlling for change in sleep hours). Equivalently, the mediating effect can be assessed by the product of the regression coefficient from change in sleep hours regressed on the intervention and the partial regression coefficient for change in sleep hours when change in performance is regressed on both the intervention and change in sleep hours. To simplify the mediation analysis, regression adjusted change scores were created for sleep hours and performance by regressing the respective post-intervention scores on the respective pre-intervention scores. The resulting residual for sleep hours is the regression adjusted change in sleep hours and the resulting residual for performance is the regression adjusted change in performance (Cohen et al. 2003).

First, we estimated the effect of the intervention on change in sleep hours, B = 0.82, t(285) = 6.83, p < .001, r-squared = 0.14. Workers receiving melatonin slept almost an hour more (50 minutes) per day than workers receiving the placebo. Second, the effect of the intervention on change in performance was estimated, B = 6.97, t(285) = 7.34, p < .001, r-squared = .16. Of course, this effect is essentially identical to the effect of the intervention on performance reported above (the slight difference is due to the small difference on the pre-intervention measure of performance between the placebo and melatonin groups). Lastly we estimated the partial effect of the intervention on performance, B = 5.34, t(284) = 5.38, p < .001, partial r-square = 0.09, and of the partial effect of change is sleep hours on performance, B = 1.99, t(284) = 4.37, p < .001, partial r-square = 0.06. The mediating, or indirect, effect of change in sleep hours on change in performance becomes 1.63 (6.97-5.34 or, alternatively, .82 x 1.99). This coefficient for the mediating effect can be tested for significance (Sobel, 1982). The mediating effect of change is sleep hours on change in performance is highly significant, z = 3.69, p < .001. Thus, the indirect

effect of the intervention, through the increase in sleep hours, represents about 23% of the total effect of the intervention on the change in performance (1.63/6.97).

Again, a moderating effect was found for age. When change in performance was regressed on the intervention, change in sleep hours, age, and the interaction of change in sleep hours and age, the interaction was significant, B = 0.91, t(282) = 2.90, p < .005, partial r-square = .03. Simple slopes indicated that the effect of change in sleep hours on change in performance was stronger for older workers (B = 3.11) than for younger workers (B = 0.67).

Lastly, we examined participants' perceptions of improved performance over the 30-day period. Participants' perceptions of improved performance were significantly correlated with actual change in performance, r (285) = .28, p < 001. Participants in the melatonin condition rated their performance as significantly more improved (M = 2.33) than participants in the placebo condition (M = 1.91), F(1,185) = 35.52 , p < .001, eta-squared = .11. This effect was not moderated by age. However, age was positively correlated with perceptions of improved performance, r(285) = .18 , p < .005.

CONCLUSION & DISCUSSION

This study found that melatonin improved worker performance in an industrial setting. The improvement was found using pre-post measure of job-related performance and validated by the perceptions of employees concerning their individual performance. The effect varied by worker age, and was partially mediated by an increase in sleep hours. These effects were found using a low dosage and oral administration of melatonin.

The results indicate that older workers benefited more from the intervention than younger workers. This effect was found despite the disproportionate number of younger workers in the sample (70% under the age of 40). The greater benefits to older workers possibly occurred because melatonin increased the average number of sleep hours, which diminish with age (MacGibbon et al. 2001). The increase in sleep hours was linked to improved performance. Improvement in older workers could also be explained by reduction in sleep interruption and blood-born toxins, which melatonin has been found to reduce in other studies (Lavie, 2001).

The post-test of performance was a single administration – on the 30th day of continuous melatonin usage. This could underestimate the true effect of melatonin because the hormone may provide greater benefits over time. This assertion is supported in the literature where studies found increasing benefits after several months of usage. Despite these measurement and sample limitations, the present research suggests that melatonin supplements, using relatively low dosages and simple oral administration, lead to improved sleep and improved work-related performance. Improvement in sleep accounts for some, but not all, of the melatonin-related improvement in performance. Additionally, melatonin-related improvements in sleep and performance may be stronger in older workers than younger workers.

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INVESTMENT TO REDUCE THE UPPER BOUND OF THE PROBABILITY OF SHORTAGE IN A CONTINUOUS-REVIEW (s,Q) MODEL

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ABSTRACT

Inventory shortage levels may be determined by management to meet a given service level. Shortages result into significant opportunity costs, and even perhaps actual costs. In this paper, we provide the management the option to invest to lower the probability of shortage, and thus reducing the uncertainty on the availability of supply, improving the service level, and lower the relevant cost. More specifically, we consider a well known continuous-review (s,Q) model and provide an analytical investigation on the impact of investing to reduce the upper bound on shortage probability. Explicit results are obtained and a numerical example is provided.

INTRODUCTION

Inventories are held to buffer mismatches between supply and demand processes that do not fit neatly together. Chief among these mismatches is a shortage, a failure to meet demand as it occurs. Inventories are often held, then, to prevent or reduce shortages. These inventories may be in the form of safety stock or safety lead time. In either case, a higher chance or probability of shortage requires a larger buffer; that is, larger inventories in either material or time. Of course each of these alternatives is generally accompanied by increased inventory systems costs and poorer overall manufacturing performance.

The question of shortages can be considered a matter of policy which is intimately related to the service level at which management decides to operate. Whether these shortages are backordered or simply result in lost sales is also a question for management. In either case there are significant opportunity costs, and even perhaps actual costs, that will be realized as a result of any shortage policy decided on by management. A typical policy, which is adopted in the model presented in this paper, is to constrain the probability of shortage by subjecting it to an admissible upper bound. The selection of the specific value for the upper bound is an indication of the trade-off between service level and cost that management is willing to accept. The value selected must reflect the realities of quality problems, lead-time variability, errors in shipments, transportation delays, forecasting errors, scheduling problems, inventory tracking problems, etc.

Ideally, management would like to be able to set the upper bound on the probability of shortage to an extremely small value, thus reducing the uncertainty of the availability of supply and improving the service level. One way to accomplish this is invest in programs aimed at correcting some of the problems mentioned above. This approach is evident in investments first in bar code technology and most recently in radio frequency identification (RFID) by a wide range of organizations including retailers, manufacturers, and the U.S. Department of Defense. Such investments have been documented to result in more effective forecasting and inventory control, and reduced distribution errors. This is accompanied by an overall decrease in operating costs. Thus, practice suggests that an analytical investigation of the impact of investing to reduce the upper bound on shortage probability, V, is warranted. In the next section we present a mathematical model to investigate the impact of such investment.

BASIC MODEL AND PRELIMINERIES

The basic model considered in this paper is the continuous-review (s,Q) model studied by many authors including Hadley and Whitin [1], Johnson and Montgomery [3], Wagner [4], and Hillier and Lieberman [2]. In this model, Q units are ordered whenever the inventory position (the amount on-hand plus the amount on-order minus the amount backordered) reaches the reorder level, s. It is assumed that demand for the item is stochastic and there is a fixed delivery time of known length before the order is received. Demand during lead-time is assumed to be a continuous random variable having a specific probability density function. Using notations similar, but not identical, to those in Hillier and Liberman [2], the expected total cost per unit time, c(Q,s), is shown to be

$$c(Q,s)=\frac{DK}{Q}+h\left[\frac{Q}{2}+s-D\lambda\right]+\frac{\pi D}{Q}\int_{s}^{\infty}(x-s)\,f(x)\,dx, \qquad (1)$$

where

Q = order quantity per order,

s = reorder level,

D = expected number of units demanded per unit time,

λ = lead-time, time between placement and receipt of the order,

x = demand during the lead-time, a continuous random variable,

f(x) = probability density function of demand during the lead-time,

μ = Dλ = expected demand during lead-time,

K = ordering cost per order,

h = holding cost per unit per unit time, and

π = shortage cost per unit short, independent of the duration of the shortage.

The optimum values of the decision variables Q^* and s^* are found by setting the partial derivatives of (1) with respect to Q, and s equal to zero and solving as follows:

$$Q^* = \sqrt{\frac{2D\left[K + \pi \int_{s^*}^{\infty} \left(x - s^*\right) s(x)\, dx\right]}{h}} \tag{2}$$

and

$$\int_{s^*}^{\infty} f(x)\, dx = \frac{hQ^*}{\pi D} \tag{3}$$

Since there is no closed-form solution for equations (2) and (3), we consider a special case of distribution of demand during lead-time and seek to choose an optimal policy subject to the constraint that the probability of a shortage occurring during a cycle will be less than or equal to an upper limit, V, set by the management. Specifically, we pursue the objective of minimizing c(Q,s) of equation (1) subject to the constraint that $p(D>s) \leq V$, when f(x) is uniform over the range 0 to t. In this case, the constrained optimization outlined above leads to the following results:

$$Q^* = \sqrt{\frac{2DK + D\pi t V^2}{h}} \tag{4}$$

$$s^* = t(1 - V) \tag{5}$$

$$c(Q^*, s^*) = \frac{Kh}{\pi V} + \frac{\pi D V}{2} + h\left(t - \frac{tV}{2} - D\lambda\right) \tag{6}$$

It can easily be shown that $c(Q^*, s^*)$ is a strictly convex function of V when $\pi D > th$. This function reaches a minimum at

$$V = \left\{\frac{2Kh}{\pi(\pi D - th)}\right\}^{1/2} \tag{7}$$

The V in equations (4) through (6) is a parameter which represents the upper limit of the probability of a shortage occurring during a cycle. In this model formulation, we assumed that this parameter would be constant. However, as noted in the introduction section, it does not have to be. In the next section we consider the option of investing in reducing the V parameter in the basic continuous-review (s,Q) inventory model when demand during lead-time is uniform in the range 0 to t.

THE OPTIMAL UPPER LIMIT OF THE PROBABILITY OF SHORTAGE MODEL

In this section, we consider the option of investing aimed at reducing the V parameter of the previous section. We treat V as a decision variable and pursue the objective of minimizing the sum of the investment cost of changing V and the inventory related costs. Specifically, we seek to minimize

$$c(Q,s,V)=i.a_v(V)+c(Q,s) \tag{8}$$

subject to

$$p(D>s)\leq V_0 \tag{9}$$

where i is the cost of capital, $a_v(V)$ is a convex and strictly decreasing function of V representing the cost of changing the upper value of the probability of shortage to the level V, c(Q,s) is the total inventory related cost given by equation (1), and V_0 is the original V value before an investment is made.

One reasonable approach to solve this constrained optimization problem is to fix V, optimize over Q and s to obtain $c(Q^*,s^*)$ given by equation (6), and then optimize over V. In this case the objective is to minimize

$$c(V)=i.a_v(V)+c(Q^*,s^*) \tag{10}$$

Since a_v (V) and $c(Q^*,s^*)$ are both strictly convex in V, minimizing c(V) requires minimizing the sum of two convex functions, which is also convex. It should be pointed out that we may not always be able to carry out the minimization. However, in some cases a_v (V) is sufficiently convex and c(V) can be explicitly minimized. One such case is a unique investment function case treated in the following section.

THE INVERSE INVESTMENT FUNCTION

In what follow, we assume that the probability of shortage follows an inverse investment function. In this case

$$a_v(V)=\frac{a}{V}-b \qquad for \qquad 0<V\leq V_0 \tag{11}$$

where a, b, and V_0 (original probability of shortage) are given positive constants and $b=a/V_0$. We are now ready to present the following theorem when a_v (V) represented by (11) is used in (10) for the case of uniform demand during lead-time in the range 0 to t.

THEOREM: if $0<V_0$•1, πD>th, and a is strictly positive, then the following hold:

a) c(V) is strictly convex in V.

b) The optimal probability of shortage, optimal production lot size, optimal reorder level, and the optimal expected cost are as follows:

$$V^{**} = \min\left\{V_0, V^*\right\} \tag{12}$$

$$Q^{**} = \min\left\{Q_0, Q^*\right\} \tag{13}$$

$$s^{**} = \max\left\{s_0, s^*\right\} \tag{14}$$

where

V_0 =Original probability of shortage

$$V^* = \sqrt{\frac{2\left[\frac{Kh}{\pi} + ia\right]}{\pi D - ht}} \tag{15}$$

$$Q_0 = \sqrt{\frac{2DK + D\pi t V_0^2}{h}} \tag{16}$$

$$Q^* = \sqrt{\frac{2D}{h}\left[K + t\left(\frac{Kh + ia\pi}{\pi D - ht}\right)\right]} \tag{17}$$

$$s_0 = t(1 - v_0) \tag{18}$$

and

$$s^* = t\left(1 - \sqrt{\frac{2\left[\frac{Kh}{\pi}\right] + ia}{\pi D - ht}}\right) \tag{19}$$

c) The resulting optimal total expected (amortized investment, setup, holding, and shortage) cost per unit time is

$$c^{**} = \min\left\{c_0, c^*\right\} \tag{20}$$

where

$$c_0 = \frac{Kh}{\pi V_0} + \frac{\pi D V_0}{2} + h\left(t - \frac{tV_0}{2} - D\lambda\right) \tag{21}$$

and

$$c^* = i\left(\frac{a}{V^*} - b\right) + \frac{Kh}{\pi V^*} + \frac{\pi D V^*}{2} + h\left(t - \frac{tV^*}{2} - D\right) \tag{22}$$

Proof is omitted.

NUMERICAL EXAMPLE

Suppose that the yearly demand for an item is uniformly distributed over the range 0 to 14000. Further assume that the delivery lead-time, λ, is one year, and the following parameters are,

K=$10000 per setup, h=$0.20 per unit per year, π=$10 per unit short, and μ=Dλ=7000 units. Assuming that the management has set an initial upper bound of 0.2 for the probability of shortage, V, the problem is whether or not to invest in efforts to reduce V if the cost of capital is 10 percent and the investment function follows equation (11) with parameters a=1360 and b=6800.

In this case, when we do not have the option of investing to reduce V (i.e., V=0.20), the resulting optimal lot size is 29933 and the expected total cost per year is $9120. Using the results of the theorem of the paper, the optimal value of V becomes 0.10 which yields an optimal lot size of 27368 and a total expected cost of $7440 per year. Thus, there is a reduction in the expected total cost of $1680 per year. Reduction in V from the initial value of 0.2 to 0.1 requires an investment of $6800 which costs $680 per year. The total return (before the investment cost) amounts to $2360.

CONCLUSION

This paper presents an extension of a well-known continuous-review (s,Q) model. Here we consider the upper bound of the probability of shortage as a decision variable and investigate the option of investing to reduce the upper bound of the probability of shortage. Explicit results for the optimal probability of shortage, optimal production lot size, optimal reorder level, and the optimal expected cost are obtained. Results of a numerical example indicate that significant savings can be realized when the upper bound of the probability of shortage is reduced.

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OPTIMUM CONTROL OF A PRODUCTION AND INVENTORY PROBLEM

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ABSTRACT

The direct second variational method combined with the first variational technique is applied to solve the optimum control of a production and inventory problem. Convergence rates of production, inventory and cost are obtained.

KEYWORDS

Direct second variational method; first variational technique; production and inventory

INTRODUCTION

Modern business and engineering systems are complex, nonlinear, and multi-dimensional in nature. It is important to exploit the many facets of modern control theory for the optimal management of these systems. Pontryagin's maximum principle [2] provides an essential basis for the development of computational techniques for optimal system control. However, when two-point boundary value difficulties limit the applicability of the maximum principle, we can resort to the variational methods [9,11,12]. The first variational methods, which improve the control variable sequence in the gradient direction until reaching the optimum solution, have a slow convergence rate. The second variational techniques have a fast quadratic convergence but with a limited convergence interval. To have a faster convergence rate with a wider convergence interval, the second and first variational methods can be combined.

The classical version [4,8] of the second variational method requires an iterative solution of the Riccatti equations in conjunction with the transformation equations. In a modified version, known as the direct variational method [10], the solution of Riccatti equations is not required. Hence it has the advantage of a relatively simple formulation requiring less computational time. This version is combined with a dynamic version of the first variational technique known as the functional or serial gradient technique [1,3,5,6,7].

In this paper, the variational equations of the direct second variational technique in conjunction with the first variational technique are outlined and then applied to a practical problem.

THE DIRECT SECOND VARIATIONAL METHOD

A typical optimization problem can be stated as follows. Find the function $u(t)$ such that the set of functions $x_1(t),\ldots,x_n(t)$ defined by the differential equations

$$dx_i/dt = f_i(x_1,\ldots,x_n,u,t) \quad i=1,2,\ldots,n \tag{1}$$

with initial condition $x_i(0) = x_i^0 \quad i=1,2,\ldots,n$ (2)

maximizes an integral of the form

$$J = \int_0^T g(x_1(t),\ldots,x_n(t),u(t),t)dt \tag{3}$$

where $x_1(t),\ldots,x_n(t)$ are the state variables, and t is an independent parameter such as the time coordinate.

In order to solve the above optimization problem, introduce an additional state variable $x_{n+1}(t)$, so that

$$dx_{n+1}/dt = g(x_1(t),\ldots,x_n(t),u(t),t) \tag{4}$$

with the initial condition $x_{n+1}(0) = 0$ (5)

The well known Hamiltonian function can be formulated as

$$H(x,\lambda,u,t) = \sum_{i=1}^{n+1} \lambda_i f_i(x,u,t) \tag{6}$$

where λ_i is a n+1 dimensional adjoint vector governed by the differential equation

$$d\lambda_i/dt = -\partial H/\partial x_i \quad i=1,2,\ldots,n+1 \tag{7}$$

with the terminal condition on the adjoint vector given by

$$\lambda_i(T) = \partial x_{n+1}/\partial x_i(T) \quad i=1,2,\ldots,n+1 \tag{8}$$

The optimality condition for this problem is

$$H_u(\bar{x},\bar{u},\bar{\lambda}) = 0 \tag{9}$$

where $\bar{x},\bar{u}$ and $\bar{\lambda}$ represent optimum vectors. The direct second variational method relaxes the optimization criterion given by Equation (9) and instead, generates a sequence of controls $u^{(k)}(t)$ approaching the optimal in a quadratic fashion. The superscript k represents the iteration number in the sequence.

Consider an initial non-optimal guess (x,λ,u) for the variables involved in the problem. Expanding the function H_u about (x,λ,u) in Taylor's series gives an estimate of the control which directs the system to an optimum [9]. Neglecting terms of second and higher order, the Taylor's series approximation can be written as

$$H_u(\bar{x},\bar{u},\bar{\lambda}) = H_u(x,\lambda,u) + H_{uu}\delta u + H_{ux}\delta x + H_{u\lambda}\delta\lambda + 0(\varepsilon^2) \quad (10)$$

where H_u is the partial of the Hamiltonian with respect to the control u. H_{uu} is the second derivative of the Hamiltonian with respect to the control. H_{ux} is a n+1 dimensional column vector representing partial of H_u with respect to x. $H_{u\lambda}$ is a n+1 dimensional column vector representing partial of H_u with respect to λ.

Introducing a relaxation factor η, whose value lies between 0 and 1, Equation (10) can be written as

$$u^{i+1} = u^i - \eta^i[H^i_{uu}]^{-1}[H^i_u + H^i_{ux}\delta x^i + H^i_{u\lambda}\delta\lambda^i] \quad (11)$$

$$\text{or as, } u^{i+1} = h(x^{i+1},(\lambda^i - \lambda^{i-1}),u^i,t) \quad (12)$$

Substituting Equation (12) in our original system, given by Equations (1), (4) and (7), we have

$$dx_i^{k+1}/dt = f_i(x_i^{k+1}, h(x^{k+1},\lambda^k - \lambda^{k-1},u^k,t),t) \quad i = 1,2,\ldots,n+1 \quad (13)$$

$$d\lambda_i^{k+1}/dt = -\frac{\partial H(x^{k+1}, h(x^{k+1},\lambda^{k+1},-\lambda^k,u^k,t)t)}{\partial x_i} \quad i = 1,2,\ldots,n+1 \quad (14)$$

Improved control is computed from the relationship

$$u^{k+1} = h(x^{k+1},(\lambda^{k+1} - \lambda^k),u^k,t) \quad (15)$$

To compute the optimal control from Equation (15), estimates of x^{k+1} and λ^{k+1} are needed. One can form a predictor-corrector scheme to obtain the required estimates. Using the initial approximation u^k, estimates of x^{k+1} and λ^{k+1} can be obtained by forward and backward integration of Equations (13) and (14) respectively. One can now start the correction process by using Equation (15) to obtain better estimates of the control. Denoting by INT – j the inner iteration scheme for one predictor step followed by j corrector steps, one can form a hierarchy of schemes depending on the value chosen for j. The choice for j is based upon the balance required between the inner and outer iteration schemes and on the relative stability of the system under consideration. An *a priori* value for j is difficult to estimate and an insight is provided through the numerical example solved in the next section.

The step by step procedure for using the second variational scheme can now be summarized as follows:

1. Obtain an initial estimate for the control, by using the functional gradient technique.
2. Integrate Equations (1) and (4) forward, and Equation (7) backward.
3. Compute and store H_u, H_{uu}, H_{ux} and $H_{u\lambda}$ at all t values.
4. Integrate Equation (13) forward and Equation (14) backward.

5. Compute improved control by using Equation (15).
6. If norm of H_u is less than a predetermined amount, terminate the program; otherwise go to step 7.
7. Depending on the INT scheme chosen, either go to step 2 or step 5.

A PRODUCTION AND INVENTORY PROBLEM

Assuming the sales $S(t)$ is known with certainty, the rate of change of inventory level $I(t)$ is the difference between production and sales at that time and can be represented by the differential equation

$$dI(t)/dt = P(t) - S(t) \tag{16}$$

where $P(t)$ is the production rate at time t. The problem is to minimize the cost function

$$C_T = \int_0^T [C_I (I_m - I(t))^2 + C_p \exp(P_m - P(t))^2]dt \tag{17}$$

where C_T is the cumulative cost of production and inventory. C_I is the inventory carrying cost. The quantity I_m can be considered as the optimal inventory level. C_p is the minimum production cost which occurs when the production rate equals P_m. The quantity P_m can be considered as the capacity of the manufacturing plant. Since the plant is designed for a capacity P_m, an increase in production level from P_m may require additional equipment and manpower and thus can be very expensive. On the other hand, a decrease in production level can be equally expensive due to the maintenance of the unused equipment and excess manpower under contractual agreements. I_m and P_m can be considered as the desirable inventory and production levels respectively. Let us assume the sales forecast is known by the linear relation

$$S(t) = a + bt \tag{18}$$

The initial inventory is given by $I(0) = C$ (19)

Reformulating the problem to conform to our general notations, let

$$x_1(t) = I(t) \tag{20}$$

$$u(t) = P(t) \tag{21}$$

Introducing an additional state variable $x_2(t)$ to represent cost at time t, we have the differential equations

$$dx_1/dt = u(t) - a - bt \tag{22}$$

$$\text{with } x_1(0) = 0 \tag{23}$$

$$\text{and } x_2(t) = \int_0^t [C_I (I_m - x_1(t))^2 + C_p \; exp\; (P_m - u(t))^2]dt \tag{24}$$

Our problem now becomes the minimization of $x_2(T)$, where

$$dx_2(t)/dt = C_I (I_m - x_1(t))^2 + C_p \; exp\; (P_m - u(t))^2 \tag{25}$$

$$\text{with } x_2(0) = 0 \tag{26}$$

Equations (22) and (25) are the transformation equations representing the two state variables $x_1(t)$ and $x_2(t)$. $u(t)$, which represents production at time t, is the control.

This is a two dimensional state variable problem with one dimensional control. Introducing a two dimensional adjoint vector and formulating the Hamiltonian function, we have

$$H = \sum_{i=1}^{2} \lambda_i f_i \tag{27}$$

$$\text{where } f_1 = u(t) - a - bt \tag{28}$$

$$f_2 = C_I (I_m - x_1(t))^2 + C_p \; exp\; (P_m - u(t))^2 \tag{29}$$

By applying Equation (7), the differential equations governing the adjoint vector are

$$d\lambda_1/dt = 2\lambda_2 C_I [I_m - x_1(t)] \tag{30}$$

$$d\lambda_2/dt = 0 \tag{31}$$

By applying Equation (8), the terminal conditions on the adjoint vector are

$$\lambda_1(T) = 0 \tag{32}$$

$$\lambda_2(T) = 1 \tag{33}$$

The partials of the Hamiltonian obtained by differentiation of the Hamiltonian function are

$$\partial H/\partial u = \lambda_1 - 2\lambda_2 C_p [P_m - u(t)]\; exp\; [P_m - u(t)]^2 \tag{34}$$

$$\partial^2 H/\partial u^2 = 2\lambda_2 C_p \; exp\; [P_m - u(t)]^2 [1 + 2(P_m - u(t))^2] \tag{35}$$

$$\partial^2 H/\partial u \partial x_1 = 0 \qquad \partial^2 H/\partial u \partial x_2 = 0 \tag{36}$$

$$\partial^2 H/\partial u \partial \lambda_1 = 1 \quad \partial^2 H/\partial u \partial \lambda_2 = -2\, C_p [P_m - u(t)]\, exp\, [P_m - u(t)]^2 \tag{37}$$

Using Equations (34) through (37), improved controls can be computed from the relationship

$$u^{k+1}(t) = u^k(t) - \eta [H^k_{uu}]^{-1} [H^k_u + H^k_{uu}(x^{k+1} - x^k) + H^k_{u\lambda}(\lambda^{k+1} - \lambda^k)] \tag{38}$$

This problem is solved with the following numerical values.

a = 2, b = 1, C = 5, C_I = 0.1, Δ = 0.01, I_m = 10, C_p = 0.001, P_m = 5, T = 1.

The initial guess for the control was $u_{initial} = 4.0$. Runge Kutta integration formula with a step size of 0.01 is used to integrate Equations (22), (25) and (30). A step size of -0.1 is used in the first variational technique for 10 iterations before switching to the direct second variational technique. A value of 0.05 for η and an INT – 1 scheme are used for the second variational scheme. The problem converges to optimum in 35 iterations. Convergence rates of Production, Inventory and Cost are shown in Figures 1 through 3. The convergence rate of production in the first five iterations is rapid and the trajectory at the 5th iteration is close to the optimal trajectory.

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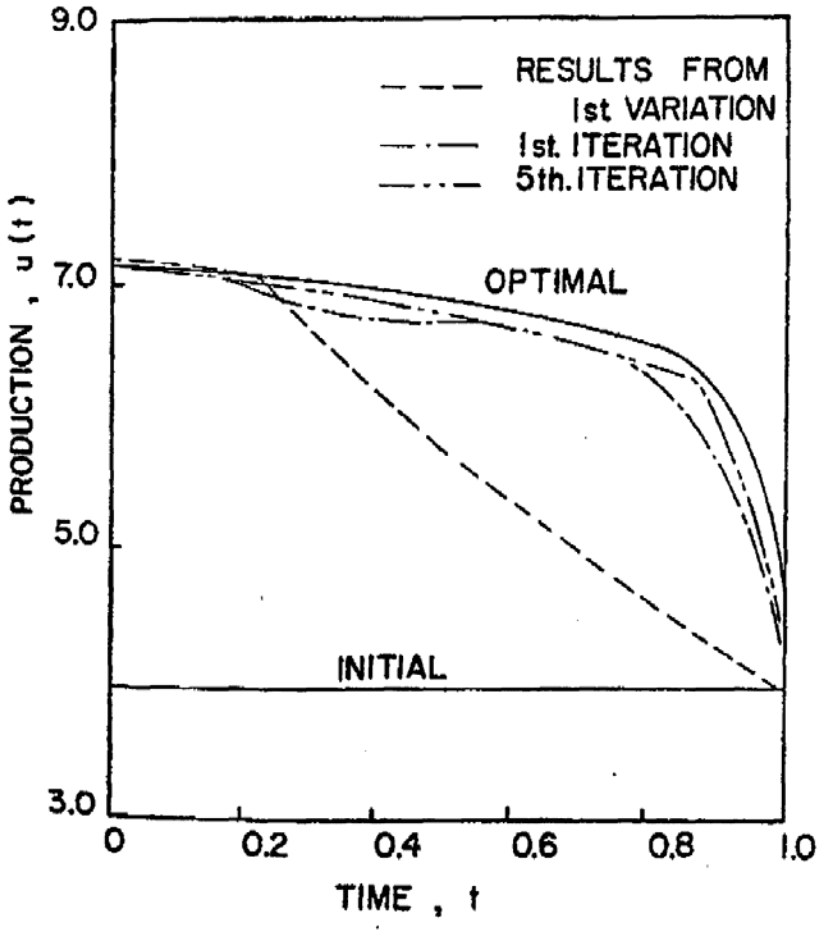

FIGURE 1: Convergence Rate of Production by the Direct Second Variational Method

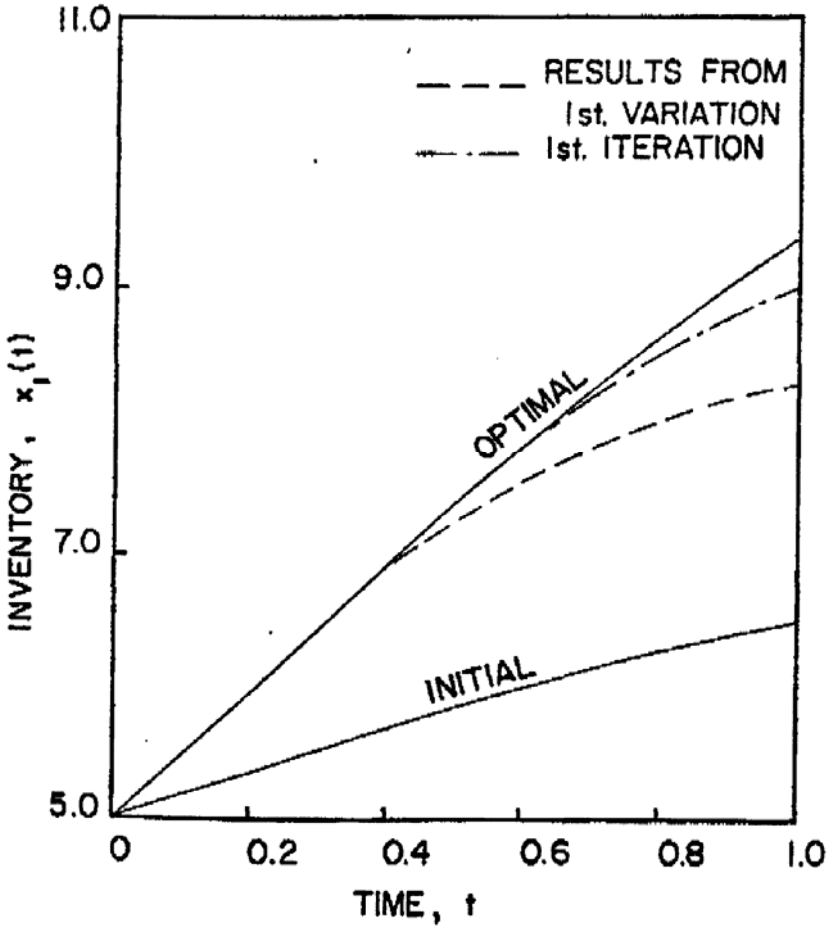

FIGURE 2: Convergence Rate of Inventory by the Direct Second Variational Method

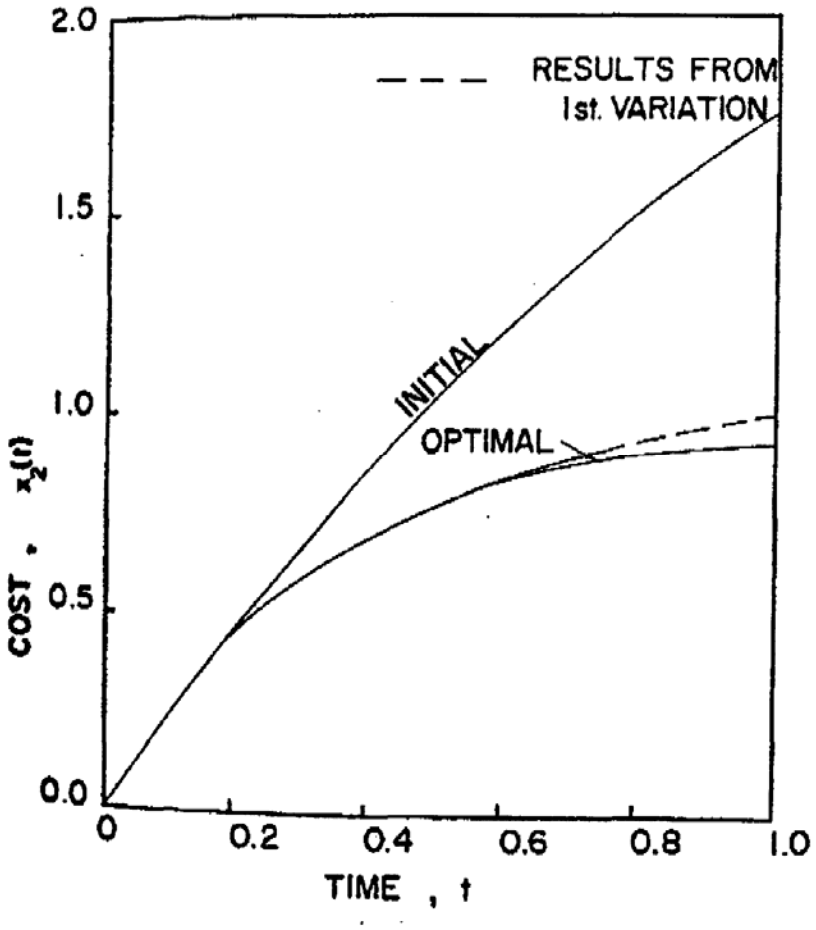

FIGURE 3: Convergence Rate of Cost by the Direct Second Variational Method

THE EPQ WITH PARTIAL BACKORDERING: A NEW APPROACH

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ABSTRACT

Previous authors have shown that if demand that cannot be filled from stock is partially back-ordered, then using the full-backordering model or assuming that all stockouts will result in lost sales can substantially increase the cost relative to using a model that recognizes the percentage of the stockouts that will be backordered. In this paper we extend our previous work on the deterministic EOQ with partial backordering to develop a model for the EPQ with partial backordering that results in equations more like those for the full-backordering extension of the basic EPQ with full backordering than those for a previous model.

Keywords: Inventory Theory, EPQ, Partial Backordering

INTRODUCTION

Any inventory control system has to determine when and how much to order. The model that is by far the best known is the classic square-root economic order quantity (EOQ) model. While the reasonableness of this model's assumptions has been criticized, it is widely and successfully used in practice. Further, it forms the basis for many other models that relax or adapt one or more of its assumptions, including the continuous receipt or EPQ model.

A key assumption of the basic EOQ and EPQ models is that stockouts are not permitted. However, if customers are always willing to wait for delivery, planned backorders may make economic sense, even if they incur a cost. Relaxing the basic models' assumption that stockouts are not permitted led to the development of models for the two basic cases for stockouts: backorders and lost sales. What took longer to develop was a model for the case where only a percentage of customers are willing to wait for delivery and the rest will cancel their orders unless the supplier fills them by using more expensive alternative supply methods.

After reviewing models for the cases of all backorders and all lost sales, we briefly summarize five models for the EOQ model with partial backordering and the only paper we are aware of for the EPQ model with partial backordering. Then we present an alternative approach to modeling the problem and determining equations for when and how much or order.

NOTATION AND TERMINOLOGY

Parameters:

D = demand per year
P = production rate per year if continuously producing
s = the unit selling price
C_o = the fixed cost of placing and receiving an order
C_p = the variable cost of a purchasing or producing a unit
C_h = the cost to hold a unit in inventory for a year
C_b = the cost to keep a unit backordered for a year
C_g = the goodwill loss on a unit of unfilled demand
$C_l = (s - C_p) + C_g$ = the cost for a lost sale, including the lost profit on that unit and any goodwill loss
β = the fraction of stockouts that will be backordered

Variables:

Q = the order quantity
T = the time between orders or the length of an order cycle
I = the maximum inventory
S = the maximum stockout level, including both backorders and lost sales
B = the maximum backorder position ($B = \beta S$)
F = the fill rate or the percentage of demand that will be filled from stock

THE "PURE" STOCKOUT CASES: ALL BACKORDERS AND ALL LOST SALES

The All Backorder Case

The model under the assumption that all stockouts are backordered at a cost C_b per unit per year for the time they are backordered appears in many basic texts. The optimal values for Q*, the order quantity, B*, the maximum backorder quantity, and T*, the time between orders, are:

$$Q^* = \sqrt{\frac{2C_oD}{C_h(1-D/P))}}\sqrt{\frac{C_b+C_h}{C_b}},\ B^* = Q^*(1-\frac{D}{P})\left(\frac{C_h}{C_b+C_h}\right),\ T^* = \sqrt{\frac{2C_o}{DC_h(1-D/P)}}\sqrt{\frac{C_b+C_h}{C_b}} \quad (1)$$

Thus Q* and T* are those given by the basic EPQ formula inflated by a term that reflects the relative sizes of the unit inventory cost per year and the unit backorder cost per year and B* is a fraction of Q* that depends on the relative sizes of those two costs and the relative production and demand rates.

The All Lost Sales Case

Zipkin [7] shows for the basic EOQ that if demands occurring during a stockout period are lost sales rather than backorders, the optimal policy is to either have no stockouts or all stockouts, depending on which costs less. The same result can be proved for the EPQ.

MODELS FOR THE PARTIAL BACKORDERING EOQ

Since it is optimal to allow some stockouts if all customers will wait ($\beta = 1$) and it is optimal to either allow no stockouts or lose all sales if no customers will wait ($\beta = 0$), it is logical that there

will be a value of β below which one should use the optimal ordering policy for the lost-sales case – either using the basic EOQ model or never ordering at all, depending on which alternative is less costly – and above which one should allow stockouts, some of which will be backordered. Determining an optimal policy for the partial backordering EOQ problem starts with determining the minimum value of β for which stockouts should be allowed and, if β is greater than this minimum value, determining the optimal order quantity.

Models for the partial backordering EOQ problem were developed by Montgomery et al. [2], Rosenberg [5], Park [3], San José et al. [6], and Pentico and Drake [4]. These papers took somewhat different approaches to modeling the problem, differing primarily in which decision variables they focused on, although San José et al. [6], rather than assuming that β is a constant, considered a number of different "customer impatience" functions that have the property that the percentage backordered does not decrease as the replenishment date approaches. Each of the first four papers, however, resulted in equations or procedures that are somewhat difficult to use for computing the relevant decision variable values. Pentico and Drake [4] used a different set of variables that resulted in equations that are more comparable to those of the model for the EOQ with full backordering.

Modeling Inventory For The EPQ With Backordering

The only model we have found for the EPQ with partial backordering is by Mak [1]. Since his approach to the treatment of demands that occur while there is no stock but the production run has started differs from the approach we will use, we first discuss that issue.

With partial backordering, from the time the system runs out of stock until the time the next order is received (EOQ) or the next production run begins (EPQ), a fraction β of incoming demand will be backordered until the maximum backorder level $B = \beta S$ is reached.

In the EOQ models with full or partial backordering, the entire order quantity Q is received at the same time, so all the backorders can be filled at once, with the maximum inventory rising immediately to $I = Q - B$. In the EPQ model with full backordering, the order quantity Q is received in a constant stream at a rate of P. Since demands that occur during the time it takes to fill all the backorders are also backordered if they are not filled immediately, it makes no difference whether the incoming orders are filled before the backorders (LIFO) or the backorders are filled before the incoming orders (FIFO). Inventory increases at the rate of $P - D$ until the backorder is eliminated and the maximum inventory level, $I = Q(1 - P/D) - B$, is reached.

For the EPQ with partial backordering, however, whether LIFO or FIFO is used to determine the order in which demands are filled after the production run begins can make a difference in the net inventory level. Whether it does or not depends on the answer to an additional question: What happens to the demands that occur when there is no stock on hand but the production run has been started? If one assumes that incoming demands will be filled before the existing backorders (LIFO) and further assume that none of the existing backorders will convert to lost sales, then the net inventory level for the EPQ with partial backordering will increase at a rate of $(1 - D/P)$. This is Mak's [1] unstated assumption. If, however, one assumes, as we do, that the existing backorders will be filled before any new demands (FIFO) and further assume that only a fraction β of these new orders that cannot immediately be filled will be backordered, with the

rest being lost sales, then the net inventory level will increase at a rate of (1 – βD/P) until the backorder is eliminated and then will increase at a rate of (1 – D/P) until the maximum inventory level is reached. (If all incoming orders will wait once the production run has started, it makes no difference whether LIFO or FIFO is used.)

Mak's [1] Model For The EPQ With Partial Backordering

Mak's assumptions are the usual ones for the EPQ model with full backordering except that only a fraction β of the stockouts will be backordered, with the rest being lost sales. As noted above, he implicitly assumes that there will be no increase in either backorders or lost sales once the production phase begins, so the backorders are filled at a rate of P − D.

Mak's decision variables are T, the length of an inventory cycle, and t, the length of time from when the inventory level reaches 0 until the next production run begins. The cost function he develops is convex, and thus the optimal solution can be found by setting the two partial derivatives equal to 0 and solving the resulting equations simultaneously. He does this by developing an equation for T as a function of t and then, by using this to eliminate T from one of the equations, finds an expression for t* as a function of the parameters and then, using this, finds an expression for T*. Both of these equations are quite complicated. It must also be noted that, although Mak develops a statement of a condition that β must satisfy for the partial backordering EPQ equations to apply, that condition is not as simple as the ones developed for the partial backordering EOQ models or as the one to be developed here.

A DIFFERENT APPROACH

We use the same assumptions about costs and demand as used in the basic EOQ with full backordering model and as used by Mak [1]. However, we assume that a FIFO policy is used to fill backorders once the production run starts. As in Pentico and Drake [4], we use the variables T, the length of an order cycle, and F, the fraction of demand to be filled from stock. Using these variables, the function for the average profit per year is:

$$\Gamma(T,F) = \frac{C_o}{T} + \frac{C_h DTF^2}{2}\left(1 - \frac{D}{P}\right) + \frac{\beta C_b DT(1-F)^2}{2}\left(1 - \frac{\beta D}{P}\right) + C_l D(1-\beta)(1-F). \qquad (2)$$

Replacing $C_h(1 - D/P)$ by C_h' and $C_b(1 - \beta D/P)$ by C_b' and taking the partial derivative of Γ(T,F) with respect to T and setting it equal to 0 gives:

$$\frac{\partial \Gamma}{\partial T} = -\frac{C_o}{T^2} + \frac{C_h' DF^2}{2} + \frac{\beta C_b' D(1-F)^2}{2} = 0.$$

This gives, after some algebra:

$$T^2 = \frac{2C_o}{D[C_h' F^2 + \beta C_b'(1-F)^2]} \text{ and } T(F) = \sqrt{\frac{2C_o}{D[C_h' F^2 + \beta C_b'(1-F)^2]}}. \qquad (3)$$

Taking the partial derivative of Γ(T,F) with respect to F and setting it equal to 0 gives:

$$\frac{\partial \Gamma}{\partial F} = C_h' DTF - \beta C_b' DT(1 - F) - (1 - \beta)C_l D = 0.$$

After some algebra, this results in:

$$F(T) = \frac{(1-\beta)C_l + \beta C_b' T}{T(C_h' + \beta C_b')}. \quad (4)$$

Substituting this expression for F into equation (3), we get, after some algebra:

$$T^* = \sqrt{\frac{2C_o}{DC_h'}\left[\frac{C_h' + \beta C_b'}{\beta C_b'}\right] - \frac{[(1-\beta)C_l]^2}{\beta C_h' C_b'}}. \quad (5)$$

We note that, with the replacement of C_h by C_h' and C_b by C_b', these are the same equations for T* and F(T*) as were found in Pentico and Drake [4] for the EOQ with partial backordering.

T* for the partial backordering model must be at least as large as T* for the basic EPQ, so:

$$\frac{2C_o}{DC_h'}\left[\frac{C_h' + \beta C_b'}{\beta C_b'}\right] - \frac{[(1-\beta)C_l]^2}{\beta C_h' C_b'} \geq \frac{2C_o}{DC_h'}$$

After some algebra, this leads us to the following conclusion: For the equations for T* and F* to be give the optimal solution, we must have:

$$\beta \geq \beta^* = 1 - \sqrt{\frac{2C_o C_h'}{DC_l^2}}. \quad (6)$$

We note that, with the replacement of C_h by C_h', this is the same condition derived by Park [3] and Pentico and Drake [4] for the EOQ with partial backordering.

It is interesting, and encouraging, to note that the form of the equation for T* in (5) is similar to the equation for T* for the full-backordering case given in (2): Similarly, the equation for the optimal value of F* in (4) is logical in that it reflects the relative sizes of the cost of not filling a unit of demand from stock and the cost of filling a unit of demand, whether immediately from stock or eventually by being backordered.

Procedure for determining the optimal values for T, F, Q, I, S, and B

1. Determine β*, the critical value for β, from (6).
2. a. If $\beta \leq \beta^*$, determine T from the basic EPQ model and determine the optimal cost of allowing no stockouts. Compare this with the cost of losing all demand, $C_l D$, to determine whether to allow no stockouts or all stockouts.

b. If $\beta > \beta^*$, use (5) to determine the value of T* and substitute it into (4) to determine the value of F*.

3. Determine the values of the other variables as follows:
   Total demand during a cycle = DT*
   Maximum inventory level = I* = F*DT*(1 – D/P)
   Maximum stockout level = S* = (1 – F*)DT*(1 – βD/P)
   Maximum backorder level = B* = βS*
   Order quantity = Q* = F*DT* + B*

CONCLUSION

As noted by several previous authors in the context of the EOQ model, determining the optimal ordering and stockout quantities when demands that can not be filled from stock are partially backordered is a much more complicated problem than for the cases in which all stockouts are either backordered or result in lost sales. As shown here, the same is true for the EPQ model. However, by changing the decision variables from Q, the order quantity, and S, the stockout level, to T, the time between orders, and F, the fill rate, we have developed a model with equations that are more like those for the basic EPQ model and its full-backordering extension and are much easier to solve than the equations developed by Mak [1].

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BENCHMARKING SUPPLIERS USING DATA ENVELOPMENT ANALYSIS

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ABSTRACT

Benchmarking is a popular tool adopted by organizations to understand how well they are performing relative to their competition. It is also used to identify what management practices are worthwhile to apply in one's own firm when aiming to reach desired performance goals. Despite widespread interest in benchmarking, one study reports that 95 percent of survey respondents believe that most companies don't comprehend benchmarking execution. To assist firms with benchmarking implementation and to help firms find the "best" companies to emulate, this research proposes an analytical framework and tests it in a population of suppliers to a common customer firm.

Keywords: benchmarking, data envelopment analysis, total quality management

INTRODUCTION

Benchmarking is one of the most popular tools adopted by organizations to understand how well they are performing relative to their competition. It is also widely used to identify what management practices are worthwhile to apply in one's own firm, when aiming to reach desired performance goals. Benchmarking has been defined as "the search for industry best practices that lead to superior performance" [4, p. 12] but it can also be construed as the continuous pursuit of reference points in response to rapid changes in market, technology, and competitive circumstances. The benchmarking process consists of scrutinizing practices and establishing metrics, where practices are defined as the processes that are employed and metrics are the quantified result of instituting the practices [4]. Benchmarking has been included in the Malcolm Baldridge National Quality Award (MBNQA) criteria, validating its widespread use [12].

Benchmarking is usually triggered by a company's need for information that arises due to: internal problems uncovered by quality management programs, the need for cost reduction, efforts to improve firm productivity, changes in management, the introduction of new processes or products, and/or competitive incursions that require reconsidering prevailing strategies. The external inquiry and comparison of practices and performance among organizations allow a manager to compare internal functional operations with achievements of the same business concern in other firms. The aim is to identify those companies that exhibit exceptional execution in functional areas designated for measurement and comparison, so that these exemplars' practices and processes can be assessed and potentially adopted. The expectation is that process substitution or strategic redirection will lead to improved performance [14].

Benchmarking can be performed at the competitive, industry, or best-in-class level. Previous studies of benchmarking have addressed such issues as: how to perform benchmarking [3], what to benchmark [15], decision support systems for benchmarking [13], and the relationship

between benchmarking, learning orientation, and a firm's operational and business performance [18]. The latter used structured interviews to gather information from 660 European manufacturing plants. Regression analyses showed a clear link between benchmarking use and two composite measures of operational and business performance. Firms reporting an organizational learning orientation were also more likely to be benchmarking users. The study underlined the important role of benchmarking in continuous improvement efforts.

Despite the numerous books and articles written about benchmarking (especially 'how to'), [3] report that 95 percent of their survey respondents believe that most companies don't comprehend benchmarking implementation. Their findings complement the conclusions of other studies that the collapse of many quality management programs hinged on breakdowns in execution rather than shortcomings in management practices or philosophy [2] [7] [8]. To prevent these implementation failures from occurring, and to help firms find the 'best' companies to study and emulate, an analytical framework for identifying the 'best practice' and 'best peer' companies is needed. This research proposes such a framework and highlights the two firms surveyed that emerged as a 'best peer' supplier for nearly every other firm in the database.

WHAT IS DEA?

Data Envelopment Analysis (DEA) is a linear-programming-based methodology that can evaluate multiple inputs and multiple outputs to calculate a ratio (performance measure) of total weighted output to total weighted input; this ratio, generated from actual field data, is the relative efficiency of a decision-making unit [5] [6]. A decision-making unit (DMU) can be any economic agent with limited resources, aspiring to attain specified performance goals with as few input expenditures as possible. A primary advantage of DEA is that the procedure calculates a combined index of overall performance using multipliers (weights) that maximize each DMU's efficiency score, relative to other DMUs in the comparison set. This means that the multipliers can vary from firm to firm (DMUs), which allows the comparison to account for structural differences among organizations. Structural differences are system-wide features of a firm's production and institutional processes where overall firm performance is influenced by nonlinear interactions among the network's components [9]. Structural differences may be due to different organizational goals, varying decision-making competencies among managements, better and worse communication with workers, different levels of employee morale/motivation/cooperation, diverse degrees of intelligence and learning among a firm's workers, and/or any of a number of other intangible traits that directly influence company processes [9]. These aggregate-level differences affect the efficiency with which company-wide programs (such as Total Quality Management) are implemented, and can confound performance evaluation procedures.

DEA, TQM, AND BENCHMARKING

Total quality management (TQM) has been recognized as the most effective input for world-class manufacturing and has become an 'order-qualifier' for prosperity in the marketplace [17]. TQM is defined as "an integrated system of principles and procedures whose goal is to improve the quality of an organization's goods and services" [10, p. 1681]. It is closely associated with

benchmarking as a tool for process improvement. The attention paid to TQM over the past two decades reflects industry and academic understanding that the quality of a firm's outputs will be only as reliable as the quality of its inputs. While TQM has begun to filter down the supply chain to suppliers of subassemblies, components, and parts, its primary adopters have been large corporations - often producers of finished goods. Small and medium-sized firms have been slow to adopt TQM [11]. Smaller companies frequently lack the resources to develop in-house TQM programs and to devote the labor hours required for successful implementation. Other firms, by directing TQM implementation efforts toward quality practices with limited impacts on performance rather than those more suited to their organizational structure, waste resources, even though they may attain the goal of zero defects.

DEA provides a method of identifying those suppliers who are achieving fewer defects (the output goal) with fewer input expenditures (e.g., effort, time, money) than their peer suppliers (i.e., others in the same data set). These "best practice" suppliers are those on the "efficient frontier" where no other supplier can produce a smaller number of defects except by using more of at least one of the inputs (e.g., TQM practices). DEA produces an efficiency score for each supplier, relative to the other suppliers in the database, which demonstrates who the "best practice" suppliers are and by how much the less efficient suppliers fall short. This information can be used by purchasing departments to identify which suppliers would benefit most from supplier development and to what degree improvement is possible. The "best practice" suppliers and their associated multipliers can be compared against the "inefficient" suppliers to formulate corrective strategies.

The analytical method introduced here goes one step beyond procedures presented in previous DEA research by demonstrating how suppliers can find the "best peer" suppliers to study and emulate. These "best peer" suppliers are the most efficient suppliers within the database with respect to inputs utilized (in this case, TQM practices), regardless of products produced or technology used. The method proposed provides an analytical foundation for benchmarking that can be used in both the manufacturing and service sectors.

METHODOLOGY

To illustrate the analytical method for benchmarking proposed here, data on internal quality management practices were collected from the supply base of a major manufacturer of aerospace subassemblies. The common customer firm is a division of a Fortune 500 conglomerate corporation. The division supplies various subassemblies and services to aviation customers, both military and civilian, in the government, commercial, and overseas markets. Its entire population of direct materials suppliers was surveyed. Several restructuring efforts have reduced their supply base in order to improve efficiencies and reduce costs.

Because TQM practices were the focus of the research, the survey instrument developed and tested by Saraph, et al. [16] was utilized. The items for this instrument were collected from the prescriptions of quality management scholars and gurus and judgmentally grouped into eight "critical factors of quality management" [16]. The survey instrument was tested in 20 service and

manufacturing firms in the Minneapolis-St. Paul area. Since this instrument had been tested in other research settings (e.g., [1]), it was judged to be a reliable instrument and suitable for this research.

Saraph, et al. [16] identified the following "critical factors of quality management": role of management leadership and quality policy, role of the quality department, training, product/service design, supplier quality management, process management, quality data and reporting, and employee relations. These eight factors were used in the present study to represent the practices relevant to TQM implementation. Saraph, et al. [16] also tested the factors for reliability, item-to-scale correlations, content validity, criterion-related validity, and construct validity. One construct (process management) split into two factors; after examining the items that loaded onto the second process management factor, the researcher decided to eliminate those questions from this survey instrument. The items either repeated other questions that loaded onto the first factor or else asked questions about practices that were rather outdated. Including the items dropped by Saraph, et al. [16] to improve the reliability of their instrument, a total of 16 items from the original research instrument were deleted, leaving 62 quality management practices that were included on this study's survey instrument.

The common customer firm provided data regarding the suppliers' quality conformance. These are the actual data that the customer firm uses to evaluate its suppliers' quality performance for contractual compliance and contractual renewal purposes. The customer firm records component part defectives found in source, receiving, and assembly/detail inspection, as well as any field failures that can be traced back to a part. The quarterly piece part defectives data provided were summed and converted to defective parts per million.

A survey instrument composed of the quality management constructs and practices described earlier was used for data collection purposes. After pretesting the instrument with four firms, survey instruments were mailed to 348 aerospace component suppliers. Two hundred and sixty four usable responses were returned for a response rate of 76%. Respondent firms in the usable sample ranged in size from 3 employees to 3,700 employees, with average firm size around 253 workers. Respondents were located in geographic areas across North America and represented a variety of product lines (e.g., forgings, castings, mechanical components, electrical components).

AN ANALYTICAL METHOD FOR BENCHMARKING AND SUPPLIER QUALITY IMPROVEMENT

Because quality management items and constructs were used that were tested in previous research, the same procedure as [16] was applied in operationalizing the constructs. To calculate a value for each construct, items assigned to each construct by the original researchers were averaged together. The informants' responses were converted to numerical values by assigning the numbers one through five to the responses "No Extent" through "Great Extent", respectively. Each construct was also factor analyzed and evaluated for reliability. Because component loadings all stayed within a narrow bandwidth of .884 to .581, there was no compelling reason to use the weights of the actual loadings (instead of the equal weights of an arithmetic average) in computing each construct's mean; both methods would lead to essentially the same value.

The common customer firm provided the suppliers' quality performance data. Annual quality performance data were inverted and normalized to the interval 0 to 1 to avoid scaling problems and to facilitate the interpretation of results. (The original DPPM data were measured on a scale of zero to 1,000,000 while the TQM practices were measured on a scale of one to five.) According to the transformation applied, a value of 1 for APPM (acceptable parts per million) corresponds to zero defectives (i.e., DPPM = 0), and a value of 0 corresponds to all defectives (i.e., DPPM = 1,000,000).

For each supplier, a measure of relative efficiency was calculated as the maximum ratio of weighted APPM (output) to weighted TQM practices (inputs), subject to the conditions that similar ratios for every supplier be less than or equal to one and that weights chosen for the various inputs and output be greater than or equal to zero [5]. An optimal objective function value of one for the linear fractional program employed indicates that the supplier under consideration is efficient relative to its peer suppliers. The set of all efficient suppliers are said to lie on the "efficient frontier" of the process that links TQM practices to APPM; this efficient frontier is assumed to be nonlinear. A number less than one for the DEA rating indicates that the supplier is "inefficient" relative to other suppliers in the data set. A DEA rating of zero would signify a totally inefficient supplier. In agreement with prior expectations, the DEA analysis showed large variations among the suppliers regarding relative efficiency; DEA scores ranged from zero to one.

With the DEA ratings calculated, the next step was to use the analytical benchmarking technique to find the "best peer" suppliers. Among the "best practice" (DEA = 1) suppliers, not all suppliers are equally influential in preventing an inefficient supplier (DEA < 1) from becoming 100% efficient. The linear program duals of the "best practice" suppliers demonstrate how significant specific suppliers in each reference set are and therefore which "leaders" would be most useful to the "laggards" in tailoring quality management strategies that lead to optimal efficiency (i.e., their "best peers"). To identify these "leaders" whose TQM practices are most relevant to an inefficient supplier, the DEA program is run, then the database is scanned, cross-efficiency scores are calculated, and the I.D. numbers of the "best peer" suppliers are recorded. The best peer supplier for supplier *k* is the one whose cross-efficiency score with respect to supplier *k* is equal to 1. The remaining DEA scores represent efficiency ratios for each supplier in the database, relative to the best peer suppliers. The "best peer" suppliers are those "best practice" suppliers who are most efficient, regardless of product sold or technology used.

RESULTS

Many suppliers in this database achieved zero defects but with excessive expenditures on TQM inputs. "Best peer" suppliers were able to achieve zero defects or very nearly zero defects (APPM ranged from .99 to 1) with minimal outlays on quality management, producing high DEA scores. Among 264 aerospace suppliers in the sample, five "best peer" suppliers emerged. Supplier A appeared as a "best peer" supplier for all but three suppliers in the data set. Supplier B surfaced as a "best peer" supplier for approximate ly two-thirds of the supplier sample. These two are firms with broadly applicable TQM programs, whom many peer suppliers can study and emulate. Because their multipliers were similar to so many other suppliers in the original DEA analysis, their cross-efficiencies changed little when computed using the other suppliers' optimal multipliers. Suppliers C-E, on the other hand, depict firms operating under unique conditions.

Their TQM practices, while useful to their own firms as well as a few others in similar circumstances, are not readily transferable to a wide variety of companies.

Both Supplier A and Supplier B made relatively little use of the eight TQM practices surveyed in attaining their high quality performance (current extent of use ranged from 1 – 3.4). However, both relied most heavily on their quality department to achieve their zero-defect (or nearly zero-defect) status. Each company was a long-time supplier to the common customer firm (more than 30 years), which gave them the experience to learn this customer's needs. The fact that both suppliers concentrated on small product niches underlines the importance of focus in perfecting both product design and process technology. Their experience enabled them to achieve efficiency as well as high quality.

CONCLUSIONS

This study has demonstrated an analytical technique that can be used in benchmarking to identify the most efficient ("best practice") suppliers, the suppliers among the most efficient with the most widely applicable TQM programs (the "best peer" suppliers), and those suppliers who are not on the efficient frontier but who could move toward it by emulating the practices of their "best peer" supplier(s). These "best peer" suppliers are those that can be imitated by their peers with the least amount of effort. This technique has immediately relevant managerial applications because it enables a purchasing manager to identify those suppliers who could benefit most from supplier development efforts. It also identifies the suppliers to study and adopt appropriate practices from, without relying on reputation or advertised excellence (e.g., a Malcolm Baldridge National Quality Award [MBNQA] winner). While an MBNQA winner has developed TQM practices suitable to its own operating circumstances, it may have nothing in common with another firm and may be an irrelevant model to benchmark oneself against. The analytical technique proposed here pinpoints firms that have something in common (e.g., organizational objectives, average educational levels of workers, extent of employee morale/motivation, etc.) with the "best peer" supplier firm. These foundational similarities suggest that the mix of TQM deployment adopted from the "best peer" suppliers will lead to greater success in attaining zero defects than a mix consisting of simply equal or maximum effort on all dimensions.

Benchmarking will continue to be a popular means of learning how to improve one's own operational processes without "reinventing the wheel." The analytical technique propos ed here will make that benchmarking process easier by identifying those firms from whom one can most appropriately adopt the "best practices." Time spent on inappropriate search and implementation efforts will be conserved and resources can be deployed to where they will have the greatest impact on an organization's goal, whether that be the attainment of zero defects or a specified return on investment.

(References available upon request from Laura B. Forker.)

A STUDY OF QUALITY MANAGEMENT PRACTICES AND SUPPLIER PERFORMANCE

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ABSTRACT

This study addresses the empirical relationship between quality management practices and quality performance by surveying the supply base of a major automotive assembler and comparing reported quality practice implementation with four performance measures used by a common customer firm to measure supplier quality. Contingency variables are also evaluated to determine their impact on supplier quality. The greater significance of these factors in explaining supplier quality performance may explain why some quality management programs are successful while others are not; it all depends on the context in which the quality management practices are implemented.

Keywords: total quality management, supplier performance, automotive industry

INTRODUCTION

Total quality management (TQM) was the focus of process improvement efforts for many firms, especially in the automotive industry, over the past 10-20 years. Early experiences with TQM were often disappointing with as many as 80% of companies that implemented it reporting little or no progress in performance [14]. Cultivation and betterment of the supply base became the focal point of many manufacturers in the 1990s, with the intention of extending the benefits gained within the factory walls to upstream trading partners. Acknowledging the continued recall of products due to quality problems (e.g., [15]), it appears that the potential of TQM, especially as practiced by suppliers, has not yet been realized. While recalls have risen throughout the automotive industry in recent years, much of this expansion has occurred due to the greater complexity of automobiles and because of their increased life spans. Given the long-term intense global competition in the automotive industry, this industry was selected for analysis of potential determinants of supplier quality performance as calibrated by a common customer firm. The customer firm evaluated supplier quality with four performance measures: quality (in parts per million), delivery (in parts per million), the frequency and severity of quality shortfalls discovered (a quality index), and annual inventory turns. Specifically, this study addressed three questions:

1) Is the implementation of quality management practices significantly related to supplier performance as measured by the four supplier performance measures mentioned above?

2) To what degree do market and product characteristics associated with a given supplier influence supplier performance as measured by the four supplier performance measures cited above?

3) To what degree do selected supplier firm work force characteristics influence supplier performance as measured by the four performance measures cited above?

DEFINING AND MEASURING QUALITY MANAGEMENT AND QUALITY PERFORMANCE: THE LITERATURE

"Quality" is a multi-faceted construct that has had many definitions attached to it over the years. Garvin [10] was one of the first researchers to group definitions of quality that had appeared in the academic and practitioner literatures according to five categories: transcendental, product-based, user-based, manufacturing-based, and value-based. Garvin [11] also summarized and classified measures of product quality that had appeared in the literature into eight dimensions: performance, features, conformance, reliability, durability, serviceability, aesthetics, and perceived quality. Examinations of quality in the 1990s initially concentrated on describing and categorizing pivotal quality practices. Saraph, et al. [13], Benson, et al. [3], and Flynn, et al. [5] developed and tested measurement instruments for what they deemed to be "critical" quality management practices including: the role of top management and quality policy, product/service design, supplier quality management, role of the quality department, process management/operating procedures, quality data and reporting, employee relations, and training. Other empirical studies have examined and reinforced an essential group of quality practices, although not always the same ones [1] [2] [4] [6] [7] [8] [9] [12]. These studies have also analyzed the link between quality management practices and quality or business performance, confirming at least a correlation if not a causal link between some quality management practices and selected quality or business performance measures. How quality or business performance has been measured has varied from study to study. With the exception of [7] and [8], most empirical studies have relied on self-reported measures of performance whether they were investigating relationships between quality practices and quality performance or quality practices and business performance.

The reliance on self-reported measures of performance calls into question published relationships between quality management practices and quality performance. This study sought to remove any potential bias by using objective data collected by a third party (a common customer firm) when examining a possible quality management-quality performance relationship. In addition, this study sought to uncover the influence of selected moderating factors such as market, product, and supplier firm work force characteristics on the quality management-quality performance relationship. There are few studies found in the quality management literature that consider such contingency factors and these factors may have a significant influence on the quality of products manufactured.

METHODOLOGY

The review of the quality management/quality performance literature led to the three research questions stated in the introduction. These research questions can be restated as a series of null hypotheses to be tested. The first null hypothesis concerns the relationship between quality management practices implemented by the suppliers to the common customer firm and their performance, as measured by the four measures stated earlier (quality in defective parts per million, delivery in defective deliveries per million, the quality index, and inventory turns).

H_{01}: The implementation of quality management practices by suppliers has no relation to supplier performance as measured by quality (defective parts per million), delivery (defective deliveries per million), the quality index, and inventory turns.

The second null hypothesis involves the influence of market and product characteristics associated with a given supplier on supplier performance as measured by the four supplier performance measures cited above.

H_{02}: Market and product characteristics associated with a given supplier will have no influence on supplier performance as measured by quality (defective parts per million), delivery (defective deliveries per million), the quality index, and inventory turns.

The third null hypothesis pertains to selected supplier firm work force characteristics that may influence supplier performance as measured by the four performance measures cited above.

H_{03}: Selected supplier firm work force characteristics have no influence on supplier performance as measured by quality (defective parts per million), delivery (defective deliveries per million), the quality index, and inventory turns.

To test these hypotheses, questionnaires were sent to 258 first-tier suppliers of a major automobile assembler in North America; 172 usable responses were received, yielding a response rate of 67%. The questionnaire included a modified version of Saraph et al.'s [13] quality management instrument that has been the basis for surveys in numerous studies covering a wide variety of industries [2] [3] [4] [6] [7] [8] [9]. The modifications made were done with the input of both purchasing and quality managers at the common customer firm to better reflect the realities of their specific environment. The market and product factors to include on the survey instrument as well as the supplier firm work force characteristics selected for the survey were also chosen with the assistance of the purchasing and quality managers at the common customer firm.

RESULTS

On a scale of 1 to 5 (Least Utilized…Most Utilized), suppliers were asked about their current extent of implementation of eight quality management practices: role of top management and quality policy, product design and development, supplier relationship management, role of the quality department, automation for quality, quality data and reporting, emphasis on quality to employees, and analysis and monitoring for quality. Of the eight quality management practices examined, respondents indicated that they utilize the quality department the most (mean = 4.12) and supplier relationship management the least (mean = 2.94). Top management plays an important role in setting and directing quality policy (mean = 4.06) but hourly employees are exposed to only a limited quality emphasis through training and employee involvement programs according to responding firms (mean = 3.37). Defective components are low, on average (mean = 1,048 ppm) while deliveries that are either incomplete and/or not on time are somewhat more common (mean = 2,458 ppm). The frequency/severity quality index is low, on average (mean = 356), while inventory turns average 19 times per year.

Each of the four supplier performance measures were regressed on the averaged quality management practices, the market and product factors, and selected supplier firm work force characteristics from the survey instrument. Supplier firms were first questioned about the predictability, volatility of market share, ease of trend monitoring, extent of new products, volatility of industry volume, accuracy of sales forecasts, and degree of new competitors to paint a picture of the market factors faced by each firm. They were also asked to characterize the primary product sold to the common customer firm: used for a critical or non-critical application in the buyer's operations; an industry standard or a custom-made product; a product made by a simple or complex production process; and a product that embodies anywhere from extensive to no process technology/innovation. Supplier firm work force characteristics asked about included: the functional affiliation of employees involved in investigating and/or solving quality problems relayed to the supplier firm by the common customer firm; the percentage of the supplier firm's work force involved in reworking defective products; the percent of the supplier's work force that are temporary workers; and the supplier firm's annual employee turnover rate.

No quality management practice was significantly related to quality (parts per million), delivery (parts per million) or the quality index. Role of top management and quality policy was significantly related to inventory turns (greater top management involvement was associated with higher inventory turns) but no other quality management practice was related to this measure. Of interest were the market/product factors and supplier firm work force characteristics that were significant. Stable industry volume in one' s market environment was positively related to fewer defective parts per million on both the quality and delivery dimensions ($p < .05$). Conversely, the introduction of many new products into one' s market was associated with greater quality and delivery shortfalls ($p < .05$). Suppliers whose primary product supplied to the common customer firm embodies extensive process technology/innovation were far more likely to score lower on the quality index (i.e., have fewer and less serious defectives: $p < .05$). And, most interesting of all, suppliers who employ temporary workers to an extensive degree are significantly more prone to score poorly on the quality index (i.e., have greater and more serious defectives) than firms that rely on a permanent work force ($p < .05$).

CONCLUSIONS AND LIMITATIONS

Only a preliminary data analysis has been performed so far, however several interesting findings have emerged. Contingency variables appear to have a bigger impact on quality performance measures than do the implementation of quality management practices themselves. These factors may explain why some quality management programs are successful while others are not; it all depends on the context in which the quality management practices are implemented. One limitation of this study is that the data set is restricted to the supply base of one automotive assembler; results therefore are difficult to generalize. On the other hand, the high response rate to the survey makes the results highly generalizable to first-tier suppliers in the automotive industry. While other factors besides those selected for the survey can influence the performance measures used (quality in parts per million, delivery in parts per million, the frequency and severity of quality shortfalls discovered [the quality index], and annual inventory turns), survey limitations and the time burden required of

respondents made the coverage of all potential factors impossible to include. Additional data analyses such as structural equation modeling may confirm or refute the findings of the reported regression analyses; this remains an area for future research.

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COMPARISON OF TQM EFFECTS ON FINANCIAL PERFORMANCE AMONG EFQM QUALITY AWARD WINNERS IN EUROPE AND TUSIAD KALDER QUALITY AWARD WINNERS IN TURKEY

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ABSTRACT

Quality, efficiency and high-level corporate performance are the most important strategic objectives for organizations that aim to gain competitive advantage in the market and Total Quality Management (TQM) is recognized as one of the most effective management strategies for reaching these objectives. In this context, this study specifically focuses on how TQM affects financial performance in the organizations in point of view based on two groups of companies that had won quality awards, EFQM Excellence Award winners and TUSIAD-KalDer Quality Award winners, between 1993 and 2003.

Key words: Quality management, corporate performance, quality awards

1. INTRODUCTION

Quality, efficiency and high-level corporate performance are the most important strategic objectives for organizations that aim to gain competitive advantage in the market, and Total Quality Management (TQM) is recognized as an effective management strategy for reaching these objectives. In recent years many manufacturing and service organizations have adopted TQM to compete in markets characterized by improved quality and service attributes [1]. Many previous research emphasize that properly implemented TQM can be a vehicle that allows organizations to fit into a competitive environment [2, 3].

TQM is a management philosophy aimed at assisting an organization in producing quality goods and services efficiently. Ross describes TQM as an integrated philosophy; requiring managerial proactiveness in customer orientation, rework reduction, employee involvement, and supplier relationships [4]. Additionally, Madu defines TQM as “managing the entire organization so that it excels in all dimensions of products and services that are important to the customer” [5]. Throughout the relevant literature, TQM is described as a collective, interlinked system of quality practices that is associated with corporate performance [6]. To summarize, the role of quality has changed from having emphasis on just quality of products/services to its current emphasis as a key component of strategic business planning as well. Based on a comprehensive review of the literature, this study specifically focuses on how TQM affects financial

performance in the organizations in this larger point of view based on two groups of companies that had won quality awards, EFQM Excellence Award winners and TUSIAD-KalDer Quality Award winners, between 1993 and 2003.

The paper is organized as follows. Part one gives a review of the literature about the link between TQM and financial performance and presents financial performance indicators. Part two presents the empirical study and its results. After the limitations, conclusions are presented in the last part.

2. THE LINK BETWEEN TQM and FINANCIAL PERFORMANCE

One of the most essential areas in corporate performance is financial performance. Corporate performance is conventionally defined as the achievement of financial and market share objectives and is measured through market growth and financial performance [7]. Sluti and Adam define corporate performance as a combination of operational and financial performance [8, 9].

There have been concerns about whether TQM brings real economic advantage to firms. While there are some studies showing negative or neutral effects of TQM, most studies give strong evidence that support TQM's positive impact on financial and operating performance. For example, Hendricks and Singhal, Easton and Jarrell, Samson and Terziovski ,Adam et al., Ippolito, Jacobson and Aaker , Capon et al., Christiansen and Lee, Mohrman et al., Ittner and Larcker, Hendricks and Singhal, and Hildenbrandt and Buzzell show that there is a statistically significant positive correlation between improved financial performance and TQM programs [10-23].

According to Shetty, when a firm acquires a reputation about high quality products and services, the elasticity of demand can decrease and this result can give firm an opportunity to charge higher prices and earn higher profit [23]. The other similar result comes from Handfield et al.'s study. They indicate that improved product quality and efficiency increase the return on assets, which lead to increase profitability. In the similar vein, in Deming Chain Reaction, quality improvement gives firm a competitive advantage to offer low prices in the market, which means that low prices can increase market share and sales [24]. Another research made by the Gallup Poll showed that 162 of the 601 senior corporate quality executives applying TQM indicate "significant increased profitability and/or increased market share" [5]. In another perspective, Douglas and Judge found that hospitals operating with relatively high structural control exhibited stronger relationships between the TQM practices and financial performance of hospitals [25].

Several financial outcome indicators have been associated with the effectiveness of TQM efforts. For instance, Reeves and Bednar have broadly classified these as indicators that concern themselves with a firm's increased internal efficiency and measures that focus on external effectiveness [26]. Commonly identified internal efficiency indicators directly attributable to TQM processes are employee productivity, manufacturing costs, and inventory costs [27, 28]. The most popular external efficiency indicator is market share, which for Juran is the

fundamental test of a TQM effort, since improved product quality arising from TQM efforts should necessarily result in better sales and hence a better market share [29]. At that point, Mohrman and et al. used cost of manufacturing, inventory turnover, and two employee productivity indicators as internal efficiency measure, which are total productivity and sale per employee. Their study revealed that there was a significant relationship between TQM and market share. However, no significant relationships were observed between TQM and return on investment, return on sales, and return on assets, but return on equity [18].

Easton and Jarell revealed that there was clear evidence that the long-term performance of firms that implemented TQM was improved and they believed the evidence of improvement was particularly strong when the overall analysis was considered [11]. They used net income, operating income, inventory, and sales per employee as accounting variables in their study. As another example, an EFQM winner, SGS Thompson Co., calculated the impact of TQM practices on corporate performance between 1992 and 1995. It simulated the situation what if they did not apply TQM and the firm found that its net revenue, inventory turnover, average revenue return time, net profit, and total costs divided by sales have radical improvements thanks to TQM.

Lately, despite the widespread popularity, TQM has received its share of bad press from management gurus for delivering lackluster economic returns. Articles in the *Business Week, Economist, Fortune,* the *Wall Street Journal* and *USA Today* talk negatively about TQM impacts on the financial performance of the firms that have adopted it [21]. But as Hendricks and Singhal point out, the disillusionment and disappointment with TQM is usually the result of unrealistic expectations and miss applications [21]. These expectations are often compounded with poor implementation that includes; allowing external forces to drive the TQM initiative, a desire for awards, considering TQM separate from daily activities with functions. Their research on quality award winners showed that, when implemented effectively, TQM produces dramatic improvement in financial performance. For example, those with TQM had 38% higher operating income than those without TQM. This is consistent with MBNQA economic research, which has shown that 71% of winners outperformed the S&P 500 index [30].

Yet, stock market reacts positively to winning quality award announcements. Hendricks and Singhal stated that the reaction was particularly strong in the case of small firms, and awards given by independent organizations such as Malcolm Baldrige, Philip Crosby etc. The statistically significant positive mean abnormal change in the stock prices on the day of the announcements suggests that winning quality awards conveys good news about the effectiveness of firms' quality improvement programs [20].

Another performance indicator is the percent change in operating income, which equals net sales less cost of goods sold and selling administrative expenses. This measures the profits generated from operating income. Operating income is influenced by changes in the growth rate and efficiency. Growth is measured by estimating the percent change in sales, total assets, and employees. Improvement in efficiency is measured by estimating the percent change in return on sales and return on assets. Return on sales is the ratio of operating income to sales and measures the amount of profit per dollar of sales. Return on sales could improve because the firms are able

to increase prices and/or reduce costs. Return on assets is the ratio of operating income to assets. It measures how profitably assets are being used [21].

Additionally, Kaynak implemented return on investment, sales growth, profit growth, market share, and market share growth as financial performance indicators in her study [31]. General Accounting Office (GAO) used market share, sales per employee, return on assets, and return on sales as sub financial performance indicators in their comprehensive study in 1991 [32]. Similarly, Evans and Jack include returns on investments, returns on assets, operating profit rates, and other profitability and liquidity indicators in their research [33].

On the basis of similar previous studies given above, we considered market share, operating income, sales, total assets, total liabilities, sales per employee, return on assets, return on sales, profit growth, net profit, stock market price and return on investment as financial performance indicators. Hypotheses proposed at that point are as follows.

H1: Market share differs after TQM programs.
H2: Operating income differs after TQM programs.
H3: Sales differs after TQM programs.
H4: Total assets differ after TQM programs.
H5: Total liabilities differ after TQM programs.
H6: Sales per employee differs after TQM programs.
H7: Return on assets differs after TQM programs.
H8: Return on sales differs after TQM programs.
H9: Profit growth differs after TQM programs.
H10: Net profit differs after TQM programs.
H11: Stock market price differs after TQM programs.
H12: Return on investment differs after TQM programs.

3. METHODOLOGY

3.1. Participants

There are lots of companies that declare that they thoroughly apply TQM in the business world. In order to be sure we were studying companies competent in TQM, we preferred to use quality awards as an approval criterion in this regard. For this reason, this study analyzed EFQM and TUSIAD-KalDer Quality Award Winners between 1993 and 2003 (since the awards have been established) as the best TQM practitioner companies in Europe.

Questionnaires with a cover letter explaining the main objective of the study were sent to 53 of 61 EFQM winners and 28 of 33 TUSIAD-Kalder winners by mail and e-mail. Companies that did not respond before the deadline were followed up by phone or e-mail. Winners that had merged with another organization were excluded from the study. The response rate for EFQM companies was 24.53%, and for TUSIAD-KalDer companies, it was 46.4%. Questionnaires were directed towards especially quality managers/directors in each organization. Of the 87%

respondents were reported their titles as quality directors and of 13% them were strategic planning manager or the president.

3.2. Questionnaire

The first part of the questionnaire includes six descriptive questions such as duration of applying TQM, duration of applying award models, number of employees, and the main reasons for the organization's excellence. The second part of the questionnaire contains a matrix including financial sub-performance indicators in rows. In the columns, companies evaluate their seven-year performance levels based on performance indicators. The first column refers to the year before TQM was applied; the second column refers to the first year in which TQM was applied, and the remaining columns are likewise each devoted to the four following years, such that a total of five years of TQM performance is recorded on the questionnaire (Table 1). The questionnaire did not ask companies to give any numerical performance level, but only positive or negative trends. Companies were supposed to mark "+" if they showed any improvement and "-" if there was any decline in performance. The "NC" alternative was used if respondents preferred to report "no change" in relevant performance indicators. This questionnaire was selected after a pilot test. The pilot study contained two different formats, one including numerical responses, while the other one including positive or negative responses. After performing the pilot study with TUSIAD-Kalder Quality Award Winners, it was found that the response rate of the latter one was higher than the first one. Based on this finding, this questionnaire was selected to be used.

Table 1: Questionnaire including financial performance indicators

	Previous of TQM			The year of TQM			The first year after TQM			The second year after TQM			The third year after TQM			The fourth year after TQM			The fifth year after TQM		
Financial performance indicators	**+**	**-**	***NC***	**+**	**-**	***NC***	**+**	**-**	***NC***	**+**	**-**	***NC***	**+**	**-**	***NC***	**+**	**-**	***NC***	**+**	**-**	***NC***
Market share																					
Operating income																					
Sales																					
Total assets																					
Total liabilities																					
Sales per employee																					
Return on assets																					
Return on sales																					
Profit growth																					
Net profit																					
Stock market price																					
Return on investment																					

4. RESULTS

Data were analyzed in SPSS 10.0. First, reliability analysis was performed and Cronbach Alpha coefficient was found to be 0.855 for EFQM winners and 0.837 for TUSIAD-KalDer winners from indicator 1 through indicator 6. Secondly, descriptive questions were analyzed. 91.7% of EFQM winners had been using TQM for more than 5 years, and 100% of TUSIAD-KalDer winners had been using TQM in general for more than 3 years. As for EFQM winners that had been applying their quality award model, 61.5% had been doing so for 5-10 years, 15.4% for 1-5 years, and 23.1% for more than 10 years. As for TUSIAD-KalDer winners applying their quality award model, 54% had been doing so for 5-10 years, 23% for 3-5 years, and 23% for more than 10 years. The last descriptive question obtains respondents' opinions about what they considered to be the most important reason for being successful in the market. Based on their responses, TQM was shown to be the most important reason (Table 2).

Table 2: Demographic results

Duration of applying TQM	EFQM Winners (%)	TUSIAD-Kalder Winners (%)
Less than 1 year	-	-
1-3 years	8.3	-
3-5 years	-	23
5-10 years	66.7	54
More than 10 years	25	23
Duration of applying EFQM or TUSIAD-KalDer Quality Award Model		
Less than 1 year	-	-
1-3 years	7.7	8
3-5 years	7.7	46
5-10 years	61.5	38
More than 10 years	23.1	8
Number of employees		
Less than 100 employees	23.1	15
100-499 employees	38.5	31
500-999 employees	7.7	31
1000-1499 employees	-	23
More than 1500 employees	30.7	-
The reason of excellence		
By our TQM approaches	92.3	100
By the other reasons	-	-

To test the hypotheses proposed, we performed two-tailed t test with a 95% confidence interval for each population. It should be remembered that in the hypotheses, μ_1 refers to the performance level reached before TQM and μ_2 to the performance level reached after TQM. In μ_1, only the one year preceding TQM is included. On the contrary, μ_2 refers to the next six years after TQM.

On this basis, t test examines whether there are any statistically significant differences between before-TQM (μ_1) and each TQM year (μ_2) for a total of six years. In the analysis, it was assumed that variances were not equal and that correlation between variables was zero.

According to the p values given in Table 3, (EFQM winners' results are in bold and in the first row), the only statistically significant difference occurred in the *sales per employee* among EFQM winners after the third year and *market share* among TUSIAD-KalDer winners only in the fifth year. Another remarkable result of the study is that no statistically significant differences appeared in other performance indicators in either group of companies. This result raises suspicion about TQM impacts on financial performance since a strong relationship between them was expected. In another perspective, it might be considered that award winners already had a positive performance before TQM applications, and so is consistent with the view that TQM is a vital concept in the success of firms. Even though two winner groups were evaluated on the basis of similar quality award models, differences on their financial performance were found in difference sub performance indicators.

Table 3: T test p values

Indicators	Winners	The year of TQM	The first year	The second year	The third year	The forth year	The fifth year
Market share	**EFQM**	**0,370**	**0,312**	**0,786**	**0,552**	**0,765**	**0,674**
	TUSIAD-KalDer	0,462	0,653	0,095	0,131	0,131	0,019*
Operating income	**EFQM**	**0,094**	**0,345**	**0,152**	**0,312**	**0,094**	**0,094**
	TUSIAD-KalDer	0,624	0,397	0,542	0,902	0,979	0,151
Sales	**EFQM**	**0,104**	**0,817**	**0,448**	**0,104**	**0,104**	**0,104**
	TUSIAD-KalDer	0,335	0,697	0,933	1	0,465	0,168
Total assets	**EFQM**	**0,505**	**0,742**	**0,273**	**0,339**	**0,339**	**0,078**
	TUSIAD-KalDer	0,718	0,912	0,912	0,912	0,235	0,901
Total liabilities	**EFQM**	**0,734**	**0,766**	**0,734**	**0,767**	**0,767**	**0,656**
	TUSIAD-KalDer	0,563	0,563	0,411	0,411	0,082	0,563
Sales per employee	**EFQM**	**0,440**	**0,584**	**0,111**	**0,05***	**0,05***	**0,05***
	TUSIAD-KalDer	0,193	0,193	0,343	-	-	0,347
Return on assets	**EFQM**	**0,740**	**0,686**	**0,765**	**0,605**	**0,103**	**0,103**
	TUSIAD-KalDer	0,441	0,441	0,441	0,441	1	0,630
Return on sales	**EFQM**	**0,740**	**0,874**	**1**	**0,605**	**0,103**	**0,103**
	TUSIAD-KalDer	0,522	0,382	0,786	0,786	0,486	0,552
Net profit	**EFQM**	**0,216**	**0,588**	**0,216**	**0,104**	**0,104**	**0,104**
	TUSIAD-KalDer	0,699	0,735	0,228	0,228	0,740	0,265
Stock market price	**EFQM**	**0,184**	**0,184**	**0,184**	**1**	**0,184**	**0,234**
	TUSIAD-KalDer	0,391	0,391	0,391	0,215	0,391	0,080
Return on investment	**EFQM**	**0,766**	**0,646**	**0,746**	**0,424**	**0,424**	**0,424**
	TUSIAD-KalDer	0,074	0,074	0,074	1	1	0,461

* $p < 0.05$, which means that there is a statistically significant difference.
- p value cannot be produced because the standard deviations of samples are same.

5. LIMITATIONS OF THE RESEARCH

Even though this empirical study produces some important results, there are a few of limitations. First, there might have been some organizations that did not apply for quality awards, even though they properly apply TQM philosophy. Consequently, they might have been excluded from the sample in this study. The second limitation is that we were not able to reach the whole population because some companies did not complete the questionnaire. The study may therefore be perceived as a sampling study rather than a census.

6. CONCLUSIONS

In this study, we empirically examined the impact of TQM on financial performance in two groups of organizations that had won quality awards: EFQM Excellence Award winners and TUSIAD-KalDer Quality Award winners. The time period covered was 1993 to 2003. The rationale for this selection was that an institutional body (EFQM or KalDer) had judged these organizations' TQM systems as the best among applicants for the awards. For the EFQM winners, the major differences before and after TQM were seen in sales per employee indicator. Similarly, among TUSIAD-KalDer winners, significant differences appeared in market share indicator. However, no statistically significant differences appeared in other performance indicators used in this study. This result should be analyzed simultaneously by considering sample companies' total corporate performance levels. As a further research, it might a question when their total corporate performance level is high, how their performance behaves in these two sub financial performance indicators and especially in other financial performance indicators.

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Level 3: Defined	Organization produces and documents standards for both software engineering and project management processes. Organization-wide training program is implemented to ensure that all staff and managers have the knowledge and skills required to fulfill their assigned roles.
Level 4: Quantitatively managed	Organization installs quantitative project goals for quality and process performance. Managers track and analyze data to understand sources of special variation causes. Organization-wide training is executed to ensure that all staff members understand the use of statistical reasoning and techniques for process improvement and control.
Level 5: Optimizing	Formalized methods are used for changes and project management practices. Project changes are done to eliminate common causes of process variation. Project and process improvement efforts are driven by the organization's commitment to continual improvement.

1.1 Initial empirical results from the field

The applications development divisions of Boeing and Motorola achieved the results that we present in this section. Table 2 reveals the impact of CMM in terms of project and product performance measures. The data from Boeing enables one to differentiate the gains due to CMM by capability maturity levels. The data shows that the progress from a lower to a higher level resulted in improvements in all the areas tracked. The achievement of level 2 increased schedule performance by 145%. Interestingly, progress from level 2 to 3 and from level 3 to 4 more than doubled the gains experienced in the area of defects, cycle time and development costs reduction. Before we make a generalization based on Boeing's results, it is useful to consider the experience of Motorola's application developers. Table 3 provides data for the case. At Motorola, in-process defects reduction did not follow the steep growth pattern that was observed at Boeing. On the contrary, the proportion of defects that was discovered at each higher level was lower than was the case in the previous level.

Table 2: Impact of Boeing's CMM projects (Curtis [4])

	Reduction of defects	Reduction of cycle time	Reduction of costs	Project schedule
Level 1 to 2	12%	10%	8%	145%
Level 2 to 3	40%	38%	35%	24%
Level 3 to 4	85%	63%	75%	15%

Moreover, the progress from maturity level 2 to 3 in this case yielded a loss in productivity and cycle time. Overall, in the case of Motorola, the level that yielded the highest gains across all three measures was the progress from level 3 to 4. The differences in both tables reinforce the need for a more thorough study of the impact of process capability improvement on software development outcomes.

Table 3: Impact of Motorola's CMM projects (Diaz et al [5])

	Decrease of process defects	Cycle time gain	Productivity gain
Level 2 to 3	54%	-16%	-20%
Level 3 to 4	50%	85%	188%
Level 4 to 5	39%	56%	22%

2 LITERATURE REVIEW

The competitive advantage of firms is increasingly dependent on their information technology choice, deployment and use. In such contexts, software failures and poor software quality yield serious financial as well as economic consequences. Though limited, there are initial results in literature about the relationship between process maturity and process performance in the area of software development. Humphrey [8] claims that his research validates the connection between matured processes and software quality. Banker, Davis, and Slaughter [1] find that improved software quality impacts maintenance costs. Slaughter et al [12] find that software quality is linked to cost incurred during support activities during software development process. Prior research in this area could be categorized into three classes. First, some studies emphasize costs modeling. Most cost structures based studies seek to establish that software quality impacts software costs, either at the delivered product level or throughout the life of the product (life cycle costs). Second, there are studies that focus on productivity modeling. The productivity models investigate the association between productivity measures, such as cycle time and development effort, and software quality. Third, some studies are based on process modeling. Process models investigate the association between software quality and process maturity. Newer studies in the area of software development use integrated models that combine elements from two or more of the basic categories. For example, Harter et al [6] investigate the relationship between process maturity, software quality, cycle time and development effort. They find that process maturity is associated with higher software quality, but also with increase in development effort. The net effect of process maturity, they find, is the reduction of both cycle time and development effort. Krishnan et al [9] follow their example. They find that improvement of software process, deployment of initial stages front-end investments and personnel capability are associated with higher quality products.

3 THEORETICAL MODEL AND HYPOTHESES

Figure 1 shows the research model for our proposed study. Our model is closely related to the newer integrated models, such as Krishnan et al [9] and Harter et al [6], for studying software quality. The model presents the seven interactions that we will explore. The following paragraphs will describe each element of the model and the proposed hypotheses.

3.1 Process maturity

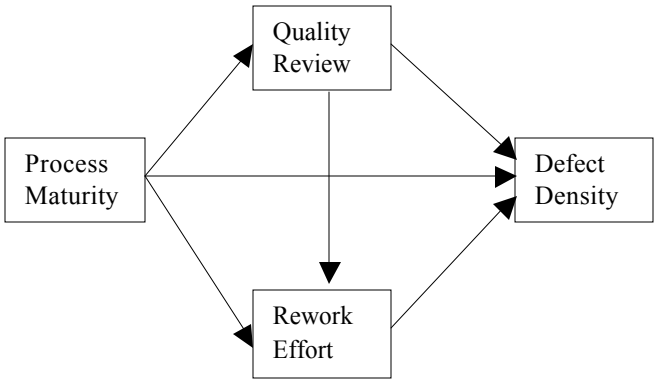
We define and measure process maturity according to the guidelines of the CMM approach. According to this practice, pre-determined processes, also called the 18 key process areas, which are associated with stages of software development, are assigned generic and specific goals as well as practices, methods and tools required to achieve the goals. The 18 key processes are grouped into five chronological subgroups called maturity levels. Whenever an organization achieves all the goals assigned to a specific maturity level, the firm is deemed to have achieved the designated maturity level, e.g. level 1, 2, 3, 4 or 5. One of the primary assumptions of process improvement through CMM is the premise that it affects product quality and productivity. Chrissis et al [3] state that a capability maturity model is based on the premise that the quality of processes highly influences the quality of a system and its products. Herbsleb et al [7] argue that organizations have achieved increased productivity and quality, improved cycle time, and more accurate and predictable schedules and budgets by improving processes. Our models will test this premise. The hypotheses addressing these issues are discussed in the following sections.

3.2 Defect density

One of the central tasks in the evaluation of software quality is the question of defining it. In literature, product quality is often defined in terms of defects found in a product during the inspection and/or during testing activities. In such cases, software quality is defined as the number of defects found per million lines of code or per thousand lines of code (Harter et al [6]; Diaz & Sligo [5]). This measure may be challenged as being a measure of the effectiveness of the internal quality inspection process rather than a measure of the quality of the software that a customer receives. We define software quality in our study as the number of predicted latent defects in a product per thousand lines of delivered source code. This quality metric is predicted, not only by the number of defects found, but also by the rate of new problems discovered during software development. Our approach assumes that every action or change to a software product discovers defects as well as ejects defects in the product. The latent number of defects in a software product delivered to a customer is estimated using historical defect data density data, gathered from inspection and peer review activities, of similar past projects and the data about customer reported unique defects (CRUD). We will examine the following hypothesis:

HYPOTHESIS 1 Higher levels of process maturity will lead to lower defect density in software products.

Figure 1: The conceptual model



3.3 Quality review

Similar to defect density, the peer review effort has not been thoroughly researched in literature. There are two primary activities that are used in software development to discover problems; these are peer review (inspections) and testing (systems and application level types). Software developers use two kinds of reviews: the formal and the informal. The peer review effort variable in our study refers to the formal kind of peer review. Formal peer reviews are structured evaluation of written code after a developer has successfully compiled them. Peer reviewers check source codes to find, count and document the errors and potential defects in them. When a peer review is completed the codes that pass are sent to the testing phase and those which fail are referred for re-work and re-review. The testing process is different from the inspection. Testing requires the functional, system and acceptance testing of all segments of source codes that have passed the peer reviews. Conventional thinking holds that as the process maturity improves the process should improve its capability to avoid and/or eliminate defects. We considered this premise in selecting the metric to use for quality review. We will use the phase containment metric as a measure of the quality review. Phase containment is defined as the ratio of problems discovered during the peer review process divided by the number of errors, that are introduced in the product, and were discovered during both testing and peer review phases. Higher phase

containment scores mean that the peer review process is discovering most of the errors introduced in a product before the testing begins.

HYPOTHESIS 2 Higher levels of process maturity will lead to higher peer review effectiveness in software products.

The next hypothesis is an extension of the former one. As the effectiveness of the peer review process improves, the logical outcome would be that the team improves its capability to catch software errors before it gets to the customer. This means that the software products delivered to customers would have lower predicted defect densities. We hypothesize the following

HYPOTHESIS 3 Higher levels of peer review effectiveness will lead to lower levels of defect density in software products.

3.4 Rework effort

Development effort has been studied in literature using mostly time and cost measures. Harter et al [6] investigate development effort in person months. Krishnan et al [9] measure development resources in terms of cost. We focus on the proportion of rework effort that occurs before products are shipped to the customer, not on those that have to be done during maintenance and support. We measure rework effort in terms of time that is required to resolve discovered defects. To our knowledge, a rigorous analysis of the interaction between rework effort and quality has not been done in literature. Rework enables us to test an alternate view or explanation for low defect density levels. Conventionally, it is believed that lower defect density occurs because problems are identified and resolved early through peer review. One can explore an alternate view that posits that higher rework effort may be impacting defect density levels more strongly than the peer review. Rework effort measure is the total hours spent on rework for a project divided by the total number of hours spent on the project. This metric enables us to reduce the impact of source code size on rework effort. Traditional quality thinking holds that rework is a form of wasted effort. Hence, we hypothesize that:

HYPOTHESIS 4 Higher levels of process maturity will lead to lower rework effort in software products.

Similarly:

HYPOTHESIS 5 Higher levels of peer review effectiveness will lead to lower rework effort in software products.

In regard to the relationship between rework effort and predicted defect density, our study investigates only one possible explanation of the phenomenon. In our view, a product that needs a higher proportion of rework effort is assumed to be the one that would have a high level of residual or latent defects. The logic that we use to validate this view is the premise that products with high defect density values yield a higher number of detected errors, which would require more rework time to resolve. We recognize that rework effort may be impacted by other variables that are not captured in our research, such as poor product experience of rework developer, complexity of the software product, and changing and incomplete requirements due to customer delays. We hypothesize the following:

HYPOTHESIS 6 Higher levels of rework effort will lead to higher defect density in software products.

4 CONCLUSION

This paper reports the design of a study that will investigate how capability maturity improvements impacts software quality and processes. Defect density is used as the measure of software quality. The model allows the investigation of the effects of process maturity on two key process activities: quality review and rework activities. This study will improve our understanding of the association between capability improvement, product quality, defect prevention, and rework.

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CAPABILITY MATURITY MODEL: INVESTIGATING SUCCESS FACTORS

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ABSTRACT

In their quest to improve the quality of software products, many firms in the software industry have implemented the capability maturity model. The penetration of the approach in the industry has increased the number of organizations in which data about software projects are gathered and analyzed for process improvement reasons. We present a model for analyzing the impact of the capability maturity model approach on software development processes. The model frames the relationship between process maturity, process review, quality rework and defect density.

Key words: Software quality, CMM, defect density, process improvement, software development

1 INTRODUCTION

In 1975 Brooks [2] observed that testing and debugging took half of all the time devoted to software development. In the early 1980s, the US Department of Defense (DoD) was concerned about the quality of its vendor's software development processes. A study of seventeen DoD software projects revealed that none was delivered on time. The study found that the average 28-month delivery commitment was missed by 20 months (Saiedian et al [11]). In 1984, the Software Engineering Institute (SEI), Carnegie Mellon University, with the assistance of Mitre Corporation was formed to help solve DoD's problems. SEI evolved Humphrey's [8] process maturity model into what was known as the Capability Maturity Model (CMM) for Software and later became known as Capability Maturity Model Integrated (CMMI) framework. SEI formalized the concepts of the approach. Software process was defined as a set of activities, methods, practices, and transformations that people use to develop and maintain software and associated documents. Software process maturity was defined as the extent to which a process is explicitly defined, managed, measured, controlled and effective. Software process performance was defined as the actual results that were achieved using the target process. Software process capability was defined as the range of results that could be expected from a software process at a given maturity level (Paulk et al [10]). The CMM differentiates the capability level from maturity level of a process. While capability level identify attributes that are expected of processes, maturity levels describe project and the process behaviors and disciplines that have to accompany capability level objectives. Table 1 presents the five maturity levels of the CMMI framework as well as brief descriptions of the characteristics of firms that are on each level.

Table 1: Maturity levels and associated behaviors (adopted from Chrissis et al [3])

Maturity Levels	State of Organizational Support
Level 1: Initial	Organization typically does not provide a stable environment for developing and maintaining software. Project success depends entirely on having an exceptional manager, a seasoned software team or competent individual programmers.
Level 2: Managed	Organization installs basic project management controls. Project commitments are based on the results of previous projects and on the requirements of current projects. Project managers track development costs, schedules, functionality and defects.

DO TYPE OF OWNERSHIP, SIZE AND QUALITY ORIENTATION OF AN ORGANIZATION MATTER?

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INTRODUCTION

The demand for ISO 9001 registration is increasing rapidly, as many companies require that their suppliers obtain it. It is also believed that attaining ISO certification is beneficial overall, helping organizations to achieve improved operational performance. In this study, we would like to investigate whether the type of ownership, size, and quality orientation have any effects on ISO 9001 certification efforts leading to TQM practices and improvement in firm's performances.

The following three research questions will be empirically investigated in this study.
Do type of ownership, size and quality orientation of a company matter in terms of answering the following three hypotheses?

1. Do ISO 9001 certification efforts have a significantly positive effect on TQM practices?
2. Do ISO 9001 certification efforts have a significantly positive effect on firm performance?
3. Do TQM practices have a significantly positive effect on firm performance?

LITERATURE REVIEW

Today, more than 400,000 firms are certified worldwide with the ISO standards (Foster, 2007). Despite its overwhelming popularity, there is still considerable confusion surrounding the effects of ISO 9001 certification efforts on the TQM practices and firm performance (Sila and Ebrahimpour, 2003).

Some claim that obtaining ISO 9001 certification is the first step towards total quality and it can be a meaningful component of TQM (Askey and Dale, 1994; Frehr, 1997; Anderson et al., 1999; Gotzamani et al., 2006). Anderson et al. (1999) content that firms seek ISO 9001 certification as a way of achieving competitive advantage through quality management. Douglas et al. (2003) indicate that ISO 9001 certification leads to improvement in quality. Naveh ans Marcus (2005) found that installing and using ISO 9001 lead to achieving competitive advantage through improved on-time delivery and reduction in cost. Han and Chen (2007) suggest that ISO 9001 registration efforts enhance quality, cost reduction, dependability, and flexibility.

Some claim that ISO 9001 certification has little relation to TQM and is a bureaucratic procedure for international trade (Brecka, 1994). Askey and Dale (1994) have found that firms tend to revert to their traditional practices after gaining certification rather than to move forward towards total quality management. McAdam and McKeown (1999) found that many small firms in

Northern Ireland are benefiting from ISO 9001; however, the majority of them are not making progress towards TQM. Poksinska et al. (2006) also found that small organizations implemented ISO 9001 with minimum effort and thus little change and benefits was achieved, losing many opportunities for improvement. Martinez-Loente and Martinez-Costa (2004) suggest that some ISO 9001 principles and TQM philosophy contradict each other and implementing both TQM and ISO 9001 simultaneously are not beneficial to firm's operating performance. Dreyfus et al. (2004) indicated that a firm's ability to implement effective TQM is only marginally enhanced by ISO 9001 efforts.

Lakhal et al. (2006) revealed that there is a positive relationship between TQM practices and firm performance. There are many studies that link the TQM approach and superior firm performance (Porter and Tanner, 1996; Escrig-Tena, 2004). Choi and Eboch (1998) found that TQM practices have a strong impact on firm's performances. Narasimhan and Jayaram (1998) found that TQM practices lead to competitiveness through improvement in competitive dimensions such as quality and cost.

METHODS

The survey instrument utilized a five-point Likert scale with 1 representing the low end of the scale and 5 representing the high end.

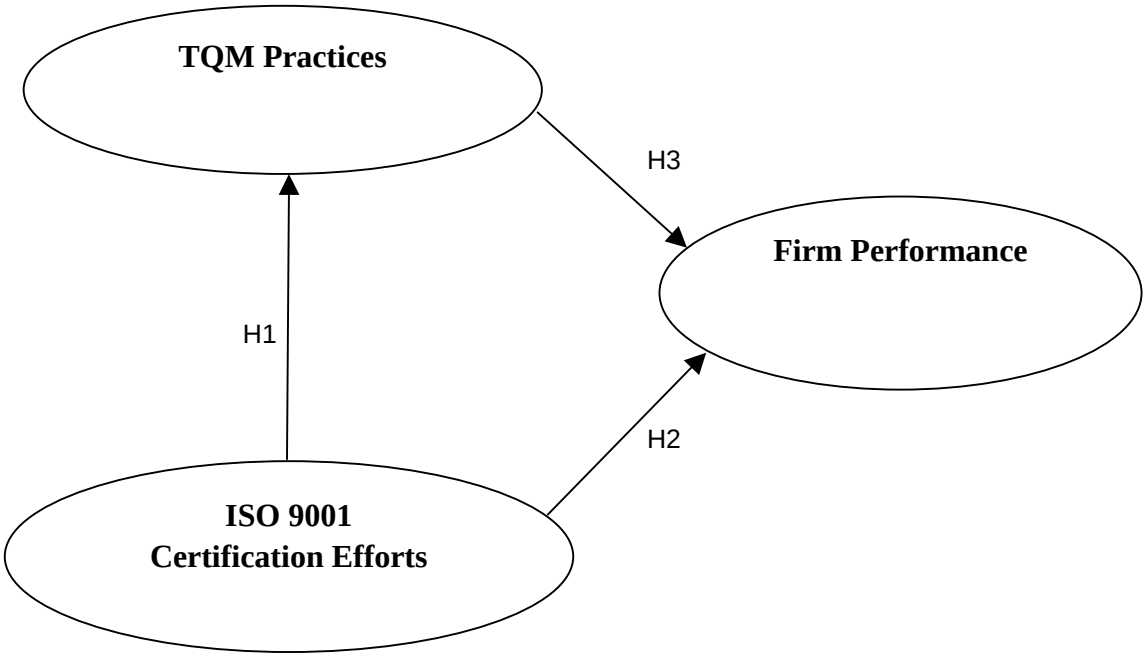
The population for this study consisted of ISO 9001 registered manufacturing firms operating in the United States with Standard Industrial Classification codes 2800 and 3600. A total of 2130 firms that belonged to the chemical and electronic industries were surveyed. The survey forms were sent to the ISO 9001 champions of these firms. Of the 2130 mailed surveys, 441 usable surveys were returned.

MULTIPLE GROUP ANALYSES

The research objective is to conduct an empirical study based on real data to better understand the relationships between ISO 9001 certification efforts and TQM practices, as well as their effects on firm performance. Thus, a model is developed and proposed based on the literature (see Figure 1). Multiple group analyses are performed on the model by splitting the data set by the type of ownership (U.S. owned vs. Foreign owned firms), firm size (Small vs. Large) in terms of the number of employees, and firm's quality orientation (TQM vs. non-TQM). TQM firms are the companies that have implemented TQM in their plants. Non-TQM firms are the companies that have not yet implemented TQM in their plants. These findings are summarized in Table 1. As can be seen from Table 1, all seven models indicate adequate model fit.

Two hypotheses (H2 and H3) are consistently supported at the .01 significance level across firm type, firm size, and quality orientation. The comparisons show that firm type, firm size, and quality orientation have a significant effect on the hypothesis H1 that is being tested. H1 is supported by firms belong to the U.S. owned firms, large size firms, and non-TQM firms. In this study, large size firms are firms with one hundred or more employees and small size firms are firms with less than one hundred employees (Pagell & Halperin, 1998). H1 is not, however, supported by the foreign owned firms, small size firms, and TQM firms.

Figure 1: Conceptual Model



DISCUSSION

This study was developed from a theoretical foundation and provides a deeper insight into fundamental theories in operations management. One important result in this research is that there is strong evidence that the ISO 9001 registration efforts enhance organizational competitiveness across the board. This is a significant contribution due to the fact that there is substantial disagreement in the literature over the relationship between the two constructs.

The results of this study agree with Anderson et al. (1999) who indicated that customer and regulatory compliance are not the only reasons for the widespread adoption of ISO 9000 in North American manufacturing companies. They found that firms pursue ISO 9001 as a means of achieving quality improvement and global competitiveness.

Table 1: Multiple group analyses.

Hypotheses	ALL	FIRM TYP		FIRM SIZE		QUALITY	
		USA	Foreign	Small	Large	TQM	Non-TQM
H1:	.26**	.23*	.10	.14	.32**	.15	.45**
H2:	.32**	.35**	.37**	.34**	.32**	.36**	.26*
H3:	.49**	.44**	.48**	.48**	.49**	.43**	.51**
Chi-Sq.:	197.8	157.4	169.0	115.6	161.3	142.9	160.8
df:	101	101	101	101	101	101	101
Ratio:	1.96	1.56	1.67	1.15	1.60	1.41	1.59
p-value:	.000	.000	.000	.152	.000	.000	.000
CFI:	.995	.994	.987	.998	.996	.996	.993
TLI:	.994	.992	.982	.997	.994	.995	.991
RMSEA:	.047	.052	.081	.032	.045	.042	.056
p-value for (RMSEA<.05)	.705	.393	.013	.874	.730	.795	.274
n:	441	206	104	142	296	236	193

Note: *: p<.01; **: p<.001
n = Sample Size

The results of the analysis also support the belief that TQM practices contribute to firm performance (Choi and Eboch, 1998; Knod, Jr. and Schonberger, 2001). ISO 9000 registration efforts and TQM practices have a significant, positive relationship when the model is tested based on all 441 responses. The overall result supports the claim that ISO 9000 might be a good first step to total quality and is a meaningful component of TQM. Conflicting conclusions, however, can be drawn, depending on the firm type, firm size, and quality orientation. Foreign owned firms, small firms, and TQM firms seem to side with critics who claim that ISO 9000 has little relation to TQM. As a matter of fact, our findings support the claim of McAdam and McKeown (1999), which states, although many small businesses in Northern Ireland are benefiting from ISO 9000, the majority of firms are not progressing towards TQM. On the other hand, larger firms, U.S. owned firms, and non-TQM firms tend to side with proponents who see ISO 9001 as a starting point for TQM and as an ongoing integral part of TQM.

Given these findings, it becomes clear why the term ISO 9001 has become more widely used than TQM in discussions of quality improvement and global competitiveness. Since ISO 9001 is much smaller in scale than TQM, it is more manageable and achievable, and yet, ISO 9001 registration efforts can give similar benefits to the organization even though they may not be in the same scale. Furthermore, companies that are ISO 9001 certified receive acknowledgement and recognition from a third party as well as their customers.

CONCLUSIONS

In this study, SEM was applied to help explain and predict the relationships between and among ISO 9001 registration efforts, TQM practices, and firm performance. A model framework was formulated based on the existing literature. Three hypotheses were proposed and tested based on the empirical data collected from ISO 9001 registered companies in the United States, and the results showed consistent support for 2 of the 3 hypotheses. This study has contributed to the existing literature on quality management. First, it identified significant research issues and addressed previously unanswered questions. Second, a model was formulated and introduced based on the existing literature to provide a clearer understanding of the relationships among existing constructs. Third, this empirical study supported or refuted existing beliefs and propositions, as well as fostered development of new theories in quality management.

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USING QUALITY FUNCTION DEPLOYMENT IN STRATEGIC CAPITAL BUDGETING DECISIONS

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ABSTRACT

This paper presents an analytic method for capital budgeting that takes into account, customer "wants "competitive analysis and cost of various alternatives. The model which is based on Quality function deployment (QFD) incorporates market segments, customer wants, engineering specifications, product components, various activities, and capital budgeting projects as rows and columns of interconnected activities. Ultimately the goal of these matrices is to prioritize projects and ensure that the projects funded are focused on satisfying customer "wants."

Key Words: Quality Function Deployment, Technology Selection, Capital Budgeting.

INTRODUCTION

XYZ Instruments, Inc. ("XYZ" or the "Company") is a manufacturer of barcode scanning equipment. In January 2005, XYZ announced its first area imaging handheld barcode scanner (see targeting primarily point of sale (retail) applications. Area imaging technology is relatively new to the barcode scanning industry, dominated by laser scanners, particularly in retail applications, where scanning needs have been limited mostly by UPC barcodes – simple linear (also called "one-dimensional", or "1D") symbology. However, recent invention and wide acceptance of two-dimensional symbologies, such as PDF417 (printed, for example, on driver licenses), forced engineers to look for a different approach in scanning barcodes. Using area-imaging technology, similar to that used in modern digital cameras, makes it possible to scan all types of traditional 1D symbologies as well as 2D symbologies. Market analysts analyzing barcode scanning industry believe that products based on area imaging technology, represent the future of the industry. In its first year of production, the new captured a significant portion of the area imaging barcode scanning market, particularly the retail market, which was the Company's primary target during design of the product. The scope of applications for area imaging barcode scanners, however, goes well beyond the retail market and includes medical, pharmaceutical, and industrial applications, where the customers not only need to scan barcodes, but also capture and store images.XYZ has currently captured 32% of the retail, 12% of the medical and pharmaceutical, and 4% of the industrial markets for area imaging barcode scanners. The Company has set up specific goals for next year to increase its market share to 40% in retail, 25% in medical and pharmaceutical, and 25% in industrial markets.

In order to achieve these goals, the Company is considering investing in new state-of-the-art product development and assembly automation tools, such as: (a) an Integrated Software Development

System, which cost $50,000; (b) a CAD system for mechanical design, SolidWorks, which costs 75,000 (c) a CAD system for designing optical and illumination parts ZeMax; which costs $100,000 and (d) Robotic tools for lens assembly automation, which costs $50,000. The purpose of this paper is to determine in which tools the Company should invest. We will use the Quality Function Deployment (QFD) method to build a model for analysis and make a proper suggestion on investment decision.

PRODUCT DESCRIPTION, AND CUSTOMER WANTS

XYZ's scanner is a typical area imaging handheld barcode scanner To scan a barcode, a user usually holds the scanner in his or her hand, points to a barcode label, and pulls the trigger. The barcode scanner acts just like a digital camera – it takes a picture of the label, stores it in digital form in its internal memory, executes image processing and barcode recognition software, and sends the results of barcode decoding to the host computer to which the scanner is connected. The most important "wants" and buying criteria for the customers of area imaging barcode scanners are: performance, price, reliability, ergonomics, and flexibility. Performance is critical because the customers want to see immediate results of scanning barcodes. Significant latency can make customers nervous and uneasy in using the scanner. Price is always critical, especially in retail applications, where the customers are used to relatively inexpensive traditional laser scanners. Price is somewhat less critical in industrial applications, where barcode scanners are usually integrated into much more expensive manufacturing or sorting systems. Reliability is very important, especially in industrial applications, where conditions are sometimes very harsh. Ergonomically, the scanners must be relatively lightweight and very convenient to use. Finally, flexibility is important, particularly in industrial applications, because of the large variety of computer systems and networks with which the scanner must be able to communicate. In the following sections we will build the QFD matrices linking the customer "wants" with the investment decisions the Company is considering in order to increase its market share.

BLUEPRINT OF THE PRODUCT DEVELOPMENT PROCESS

The marketing department initiates the product development, and product-engineering specifications are determined and specified based on the market analysis, input from customers, and established business goals. The product development is then split into four parallel activities: mechanical engineering, optical engineering, hardware engineering, and software engineering. At the end of the first stage of the development process, the prototype of the product is built and tested. If modifications are necessary (which is usually the case), the four engineering groups make proper improvements to the design and build the production prototype. At the same time, the product assembly automation tools are being built and the manufacturing assembly line is being prepared for the product. The production prototype is then tested and qualified for production. If changes are again necessary, the product is returned to the four engineering groups for further improvements. Once the production prototype is successfully qualified, the product is released to production.

THE MODEL

In Figure 1, the first QFD matrix describes the relationships between the market segments and the customer "wants'. The market segments are: point of sale (retailers); medical and pharmaceutical; and industrial applications. The customer "wants" are the customer buying criteria described above in

the Product Description section. Also shown in this matrix is the current distribution of the product among the customers. As mentioned above, XYZ's scanner was designed specifically for retail applications, therefore it should not come as a surprise that 85% of the product is sold in that market segment. Currently, 10% of the product is sold in medical and pharmaceutical market, and only 5% in industrial applications.

Compared to its main competitors, as shown in Figure 1, Metrologic has currently captured 32% of the retail, 12% of the medical and pharmaceutical, and 4% of the industrial markets for area imaging barcode scanners. The Company has set up specific goals for next year to increase its market share to 40% in retail, 25% in medical and pharmaceutical, and 25% in industrial markets, which represent a desired improvement ratio of 1.25, 2.08, and 6.25 respectively for these market segments. Taking current product distribution into a weighting factor, we calculated the normalized scores for improvement in each market segments: 67 for retail, 13 for medical and pharmaceutical, and 20 for industrial markets. Multiplying the normalized scores by the customer "wants" value for the corresponding market segment and summarizing the results, allows us to quantify the importance of the improvement for each customer buying criteria, as shown in the highlighted row of the matrix in Figure 1.

Market Segments	Current Product Distribution, %	Performance	Price	Reliability	Ergonomics	Flexibility	Metrologic	Comp 1	Comp 2	Comp 3	Comp 4	Goal	Improvement Ratio	Weighting Factor	Normalized Score, %
Point of Sale (Retailers)	85	9	9	3	3	1	32	15	3	27	21	40	1.25	106.25	67
Medical and Pharma	10	9	3	3	3	3	12	16	9	61	1	25	2.08	20.83	13
Industrial Applications	5	9	1	9	1	9	4	2	14	50	22	25	6.25	31.25	20
Total	2526	900	663	418	261	284								158.33	100
%	100.0	35.6	26.3	16.6	10.3	11.3									

Figure 1. Linking customers and their "wants"

We used the values calculated in the matrix in Figure 1 in order to weight the customer wants for the second QFD matrix shown in Figure 2. In this matrix, we use customer "wants" as rows and engineering specifications of the product as columns, and show the relationships between the customer "wants" and the engineering specifications. As a result, we quantified the importance of improving each of the engineering specifications, as shown in the highlighted row of the matrix in Figure 2. Similarly we used the values calculated in the matrix in Figure 2 to weight the importance of each engineering specification in the third QFD matrix shown in Figure 3. In this matrix, we use engineering specifications as rows and product components as columns, and show the relationships between the

		Engineering Specifications							
Customer Wants	Importance Weights	Optical Depth-of-Field	Barcode Size	Scans-per-Second	Scanner Size	Scanner Ruggedness	Bill of Materials	Cost of Labor	Set of Functions
Performance	35.6	9	3	9					
Price	26.3						9	3	
Reliability	16.6					3			1
Ergonomics	10.3				9				
Flexibility	11.3								9
Total	1323	321	107	321	93	50	236	79	118
%	100	24.2	8.1	24.2	7.0	3.8	17.9	6.0	8.9

Figure 2. Relating customer "wants" and engineering specifications

engineering specifications and product components. As a result, we quantified the importance of improvement for each product component, as shown in the highlighted row of the matrix in Figure 3.

Engineering Specifications	Importance Weights	Product Components					
		Case	Illumination Module	Camera Module	Processing Module	Software	Assembly Time
Optical Depth-of-Field	24.2		9	9	3	9	
Barcode Size	8.1		3	9	9	9	
Scans-per-Second	24.2				9	9	
Scanner Size	7.0	9		1	1		
Scanner Ruggedness	3.8	9					
Bill of Materials	17.9	3	1	1	9		
Cost of Labor	6.0						9
Set of Functions	8.9				3	9	
Total	1926	150	260	316	558	589	54
%	100	7.8	13.5	16.4	29.0	30.6	2.8

Figure 3. Relating engineering specifications and product components

We used the values calculated in the matrix in Figure 3 to weight the importance of each product component in the fourth QFD matrix shown in Figure 4. In this matrix, we use the product components as rows and the Company's business activities directly affecting the product components as columns, and show the relationships between the product components and business activities. As a result, we quantified the importance of the improvement for each business activity, as shown in the highlighted row of the matrix in Figure 4.

Product Components	Importance Weights	Activities						
		Mechanical Engineering	Optical Engineering	Hardware Engineering	Software Engineering	Prototyping	Product Testing and Qualifying	Production Automation
Case	7.8	9	3	1		3	3	1
Illumination Module	13.5	3	9	1		3	3	3
Camera Module	16.4	3	9			3	3	3
Processing Module	29.0			9		1	1	
Software	30.6			3	9	3	3	
Assembly Time	2.8	9	3	3	3	3		9
Total	1749	185	301	382	283	242	234	122
%	100	10.6	17.2	21.8	16.2	13.8	13.4	7.0

Figure 4. Relating product components and business activities

Finally, we used the values calculated in the matrix in Figure 4 in order to weight the importance of each business activity in the fifth QFD matrix shown in Figure 5. In this matrix, we use the Company's business activities as rows and the projects under consideration for investment as columns, and show the relationships between the business activities and the projects. As a result, we quantified the importance of each project, as shown in the highlighted row of the matrix in Figure 5.

Activities	Importance Weights	Projects			
		Software Development System	Solid Works	ZeMax	Robot
Mechanical Engineering	10.6		9	3	
Optical Engineering	17.2		3	9	
Hardware Engineering	21.8	3	1		
Software Engineering	16.2	9			
Prototyping	13.8	1	3	3	
Product Testing and Qualifying	13.4			1	
Production Automation	7.0				9
Total	740	225	210	241	63
%	100	30.4	28.4	32.6	8.5

Figure 5. Relating business activities and projects under consideration for investment

According to our calculations, in order to increase its market share for area imaging barcode scanners, the most important project in which to invest is ZeMax, Our calculations also show that the importance of the Integrated Software Development System and another CAD system for mechanical design SolidWorks, as our calculations show that their importance is not significantly lower than the importance of ZeMax. We do not recommend making significant investment in robotic lens assembly tooling, as our calculations show that its importance is significantly lower that that of the other projects.

BENEFIT COST ANALYSIS

Taking the cost of each investment into account, we calculated the benefit-to-costs ratios for each project as shown in Figure 6.

	Projects			
	Software Development System	Solid Works	ZeMax	Robot
QFD Score	30.4	28.4	32.6	8.5
Costs Thousands $	$50	$75	$100	$50
Benefit/Costs	0.61	0.38	0.33	0.17

Figure 6. Benefits-to-cost calculations

Taking the cost of each investment into account, we calculated the benefit-to-costs ratio for each project is shown in Figure 6.

SUMMARY AND CONCLUSIONS

This paper has presented an analytic method for process selection. The model, based on QFD, incorporates market segments, customer wants, engineering specifications, product components various activities, and projects as rows and columns of interconnected QFD matrices. We have also used cost of each project to determine a benefit-cost ratio of various project options. The model has been implemented in a manufacturer of barcode scanning equipment.

References are available upon request from \Fariborz Partovi

USING DESCRIPTIVE STATISTICS IN STATISTICAL PROCESS CONTROL

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ABSTRACT

The purpose of this paper is to demonstrate the various uses of descriptive statistical analysis in statistical process control (SPC). Some fairly well-known descriptive techniques, along with the lesser known methods, will be discussed for their potential use in SPC. A numerical example will be provided.

Keywords: Statistical process control, descriptive statistics, process improvement.

DISCUSSION

SPC is a key component of every quality philosophy, e.g., Total Quality Management, Six Sigma, etc. It is process-oriented, preventive, and helps identify types of variation in a process. SPC has several components, such as developing guidelines to run the process (i.e., standard operating procedures (SOP); describing the current process performance (e.g., using some descriptive statistics); monitoring the process over time (e.g., using proper control charts); assessing the capability of the process (e.g., using capability estimates such as capability indices); and providing review and feedback. For a more detailed description of SPC see, for example, Montgomery [11] and Duncan [4].

In this paper, we will look at the descriptive statistics component of SPC. Most SPC applications either totally ignore or do not take sufficient advantage of the use of descriptive statistics. Descriptive statistic analysis would provide valuable information about the current performance of the process, as well as providing significant input to the proper selection and use of process control and process capability methods. Descriptive statistics in a sense provide a picture of the process at a given time, i.e., what the process has done up to that point. In this regard descriptive statistics can be considered static measures, rather than dynamic measures like control charts.

Examples of the Use of Descriptive Statistical Analysis

i. The Histogram when compared to customer specification limits gives preliminary information about the process performance up to that point in graphical format, e.g., does the process seem to be meeting the customer expectations; is the process average near the customer target (if there is a customer target); how wide the width of the process compared to customer tolerance; etc.? These are all visual analyses but it could be very helpful in understanding the process performance.

ii. Calculating mean, standard deviation, skewness, kurtosis, etc., would provide additional information about the process during the period in which the sample data is gathered. For example, the estimated mean value can be compared to the customer target directly; and the standard deviation can be used to determine the width of the process, which in return can be checked against the specification limits. Skewness and kurtosis can be used to get a rough estimate of the shape of the process distribution. Skewness deals with the question of the symmetry of the curve relative to its center as measured by the average; and kurtosis describes the tendency of the curve to have long tails and a high center. A "Normal" curve is symmetric about the mean value; the skewness is zero for such a curve. The kurtosis measure for a normal curve is 3. Skewness and kurtosis measures can be computed as follows:

$$\text{Skewness} = \frac{\frac{\sum (X - \overline{X})^3}{n}}{SD_X^3} \quad (1)$$

$$\text{Kurtosis} = \frac{\frac{\sum (X - \overline{X})^4}{n}}{SD_X^4} \quad (2)$$

where X's are the individual observations, n is the number of observation, $\overline{X}$ and SD_x are the mean and standard deviation of the X's , respectively.

The measures of skewness and kurtosis are primarily used to make a quick assessment of the normality of your curve. Skewness values outside of $0 \pm \frac{7.35}{\sqrt{n}}$ or kurtosis values outside of $3 \pm \frac{14.70}{\sqrt{n}}$ are indications that the curve is not a normal curve (Holmes [6]). If the test results reveal that the process curve is not normally distributed, SPC analysis can be modified accordingly. For example, capability analysis should be carried out using the indices developed for non-normal process distribution (see, for example, Holmes and Mergen [7]), since conventional indices assume a Normal process distribution. This way the over/under estimate of the capability would be avoided.

iii. The standard deviation, which is used to measure the process width in SPC, can be estimated in a variety of different ways, depending upon what question we are trying to answer. It is crucial to use the proper estimate of the standard deviation to have the right answer for the question being asked; otherwise the analysis may lead to erroneous results. The conventional estimate of the standard deviation (equation 3) gives the total estimate of the variation that currently exists in the process.

$$\text{Standard deviation} = \sqrt{s^2} \text{ where } s^2 = \frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{n-1} \quad (3)$$

This estimate is good to check the current performance of the process with respect to meeting the customer specifications. However, the capability standard deviation of the process, i.e., the standard deviation when the process operates under only common causes of variation, could be

different than this one if the process currently is not statistically stable (i.e., in control). It is this capability standard deviation that we need to use to estimate the real capability of the process. Thus, several standard deviations should be estimated as part of descriptive statistical analysis. These estimates would be very close to each other if the process is stable; otherwise they would differ. Thus, these different estimates would then be used, for example, to generate early signals to see if the process was in control during the period under review by checking the significance of the difference of the estimators. The result of such analysis could be a valuable input for managerial planning in terms of setting proper targets for the capability of the process to reduce the variation.

One such estimate for the capability standard deviation is the one computed using mean square successive differences (MSSD) – see , for example, Neumann, et al. [13], Hald [5], Holmes and Mergen ([8] [9]). The MSSD is defined as

$$\text{MSSD} = \frac{1}{(n-1)} \sum_{i=1}^{n-1} (X_{i+1} - X_i)^2 \qquad (4)$$

Using these differences an unbiased estimate for the process variance is given by Hald [5] as

$$q^2 = \frac{1}{2(n-1)} \sum_{i=1}^{n-1} (X_{i+1} - X_i)^2 \qquad (5)$$

Then MSSD standard deviation is determined by taking the square root of the q^2. Roes, et al. [14] suggested a minor correction factor in estimating the standard deviation when the MSSD approach is used. This factor disappears as the sample size gets bigger. The significance of the difference between the conventional and MSSD variance estimates can be tested using the test given in Dixon and Massey [3]:

$$z = \frac{1 - \frac{q^2}{s^2}}{\sqrt{\frac{n-2}{(n-1)(n+1)}}} \qquad (6)$$

Values of z between ±3 indicate that the difference between the two estimates is not significant, i.e., the process seems to be stable, in other words, operating under common causes only. Z values bigger than +3 and less than -3 indicate that the two estimates are significantly different and thus the process is not stable (values bigger than +3 imply trend and long-term cycles in the process and values less than -3 imply short term cycles in the process). Since z is N(0,1), then the use of z values between ± 3 gives about 99.7% critical region for the test.

Through analysis like this process managers not only would have preliminary information about the stability of the process, but at the same time, using the smallest standard deviation estimate, they could come up with the potential capability of the process.

iv. Another test which should be part of descriptive statistical analysis is the test for autocorrelation. Use of computer controlled machines and automatic process control mechanisms seem to increase the chance for autocorrelation in the process. When the data is autocorrelated, it violates the basic assumption of the Shewhart control charts, which assume independence of the data points. Thus the check for existence of autocorrelation should be a routine part of the descriptive statistical analysis. If the process displays the sign of autocorrelation, process control techniques, such as control charts, should be modified to take into account the variation due to autocorrelation. Failure to do so would result in an erroneous conclusion about the process. See, for example, the following studies on process control with autocorrelated data ([1] [2] [10] [12]).

v. In the case of multiple process variables, the variance/covariance matrix should be analyzed as part of descriptive statistics to see if all or some of those variables are correlated. Correlated variables should be analyzed using multivariate SPC techniques to minimize the type I and/or type II error.

EXAMPLES

The first data set that is used is on viscosity. The summary descriptive statistics are given below (all data sets are available from the authors upon request).

Descriptive Statistics

Mean	=	9.1	Median	=	9.3
Std Dev .	=	0.6	SE Mean	=	0.0
Range	=	3.0	# Observ	=	310
Minimum	=	7.4	Maximum	=	10.4
Skewness	=	-0.5	Kurtosis	=	2.4
Cap SD	=	0.2	Cap Rtio	=	0.4

Mean Square Successive Difference Tests

Normal z	=	15.1	MSSD SD	=	0.2

Spec Info

LSL	=	8.4	% Under LSL	=	13.9
USL	=	10.4	% Over USL	=	0.0
Nominal	=	9.4	% In Specs.	=	86.1

As one can see, the process average is slightly below the nominal (9.1 vs. 9.4). The regular standard deviation is much bigger than the MSSD estimate of the standard deviation (0.6 vs. 0.2); and the significance test has a z value of 15.1 indicating that the two variance estimators are significantly different. This in turn implies that the data may have trend and/or long-term cycles. In other words, the process does not seem to be stable during the period the data is gathered. It also indicates that the process variation could potentially be reduced to 0.2 and the process capability be improved. The skewness test for normality indicates that the data is not quite

normal. Specification analysis shows that the process will not be able to meet the specifications 100%; roughly 14% of the data will fall below LSL.

The second data set is on the diameter of transmission covers. This data shows the sign of first order autocorrelation (Figure 1), which violates the assumption of the independence of the control charts. Thus, the autocorrelation should be modeled and removed from the data before the control chart analysis is applied.

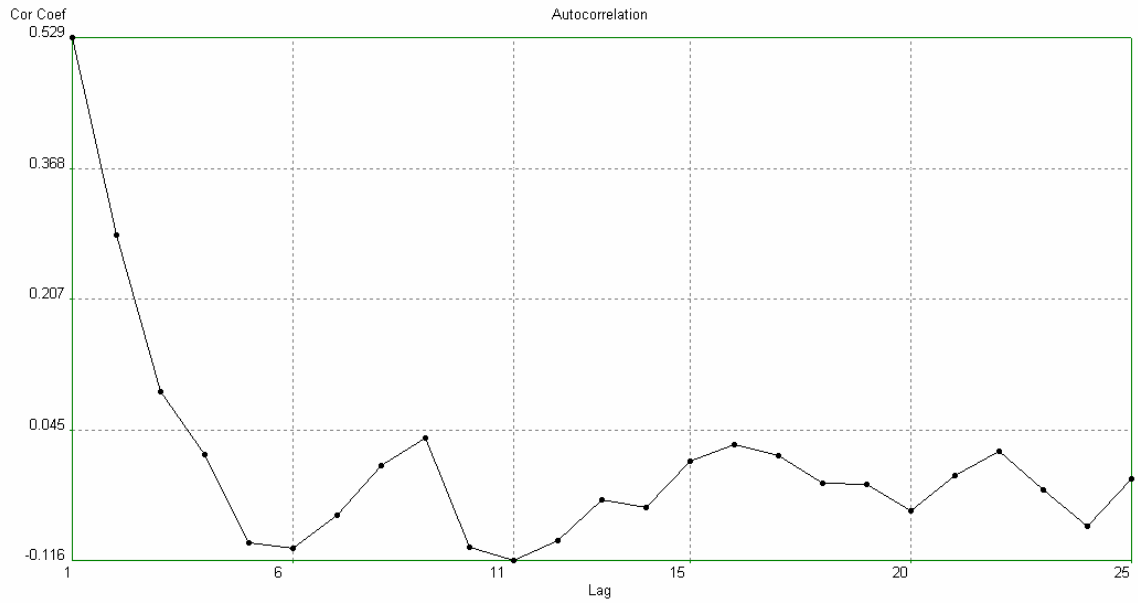

Figure 1. Autocorrelation chart.

The third data set is on the distribution of particle weight percentages for five screen sizes. The correlation matrix below shows strong correlations between some of the five variables. Thus, these correlated variables should be analyzed using multivariate SPC techniques to minimize the type I and/or type II error.

	S1	S2	S3	S4	S5
S1	1.00				
S2	0.59	1.00			
S3	0.96	0.39	1.00		
S4	0.87	0.74	0.77	1.00	
S5	0.34	-0.56	0.54	-0.01	1.00

Figure 2. Correlation matrix

CONCLUSION

In this paper we proposed more and better use of descriptive statistics in SPC. Better use of descriptive statistical analysis would make the other phases of the process control more effective

by helping choose the right process control and process capability techniques, as well as helping managers set the proper targets for process improvement projects.

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PROCESS IMPROVEMENT IN THE PUBLIC SECTOR: SUCCESS FACTORS

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ABSTRACT

The goal of this research was to identify factors found in successful process improvement efforts in the public sector. The research methodology included field research on a representative set of public sector services. Many challenges were identified that could exist in any service organization but appear to exist in greater frequency in the public sector. Other characteristics unique to the public sector pose an additional challenge. Successful program have many characteristics in common: private sector influences, little leadership turnover, a focus on culture, and a no-layoff guarantee. Additionally, improvement projects employ a formalized project structure and use basic problem solving methods.

INTRODUCTION

Many citizens and some politicians believe that government, by its nature, cannot manage taxpayer money effectively. Within the public sector, numerous individuals have devoted much of their careers to refuting this belief. These individuals have attempted to apply principles of Six Sigma, Lean, TQM, Malcolm Baldrige, and other quality programs. Most have met with mixed success, in many cases applying proven process improvement methods periodically but not systematically.

In a few cases, long standing process improvement programs have been sustained over a period of time. For example, Fort Wayne, Indiana, under the leadership of Mayor Graham Richard, has since 2000 used Lean Six Sigma to improve services. During that time, the City has saved $11 million (even while acquiring additional land and increasing population) with no tax increases.

Since the public sector offers unique challenges, administrators would be well served by understanding key factors that drive sustainable success. But, as detailed below, the most difficult barriers that could exist in the private sector occur with greater frequency in the public sector. Additional challenges, unique in the public sector, also present significant challenges.

It is clear that a program of process improvement must be customized. For example, in the Florida Department of Revenue, a program they refer to as "Six Sigma Light" was initiated in 2003. This program represents a customized version of Six Sigma using only very basic Six Sigma and Lean tools. As of 2006, they have seen an average return of a $23 for every dollar invested into the program.

The methodology employed included development and analysis of a long written questionnaire completed by about twenty public sector administrators with experience in process improvement. Extensive one-on-one interviews followed with about half of these participants.

SERVICE PROCESS CHARACTERISTICS

A substantial amount of terminology and techniques in the quality improvement arena apply to manufacturing, which complicates the application of these techniques in services. For example, the important goal of minimizing variation is unlikely to motivate a service provider since the output of a service is usually not measured precisely on a variable scale. Another important goal of minimize inventory is also not important in services.

To help public sector service providers relate to the methodologies of process improvement, unique characteristics possessed by services should be understood. Budgeting, an important public sector service, will be used as illustration. Here, inaccuracies in either direction (too high or too low) can have devastating effects. If a budget projection is too low, a project will be delayed until more funding is appropriated, or the project may be cancelled if a newly elected politician has an unfavorable opinion of the project. If the budget projection is too high, other worthwhile projects that should have been funded would be delayed or cancelled. Therefore, it is imperative that the budget projection be as accurate as possible.

A previous analysis identified common features shared by most service processes, including budgeting [1]:

- Importance of information: Delivery of information may be the main purpose of the service, which is the case in the budgeting process, and within the service process many transfers of information regularly take place. In the budgeting process, for example, information must be obtained from experts knowledgeable of the project scope and potential cost.

- Significant task variability: Service tasks, unlike most manufacturing tasks, are highly variable. For example, in budgeting, time taken to work up a cost estimate for each project component would vary depending on its complexity. Hence, many techniques known to be effective in manufacturing would not prove useful in a service improvement effort.

- Cross-functional process flows: Service processes usually flow across departments making coordination of activities especially difficult. In a budgeting process, the finance, accounting, engineering, and human resource departments, as well as outside contractors, would all be involved in the preparation of a comprehensive budget.

- Many handoffs of information: With cross-functional process flows and information having critical importance, frequent exchange of information occurs. Handing off information in any situation is fraught with peril. For example, a City manager who communicates a building's design features to an architect may use words or terms mistaken by the architect resulting in an inaccurate budget estimate.

- Numerous inspections: In many services, the reaction to frequent errors or omissions often involves the setting up of an audit or review by management or technical staff. The numbers on a budget, for example, may be reviewed for accuracy by an accountant before the budget is submitted to the legislature for approval. These inspections increase the cost of providing the service, delays service completion, and often have little effect on quality.

- Hidden benefits and costs: Quantifying the benefits of good or bad service in monetary terms can be complicated, if not impossible. In a budgeting process, inaccuracies will likely cause the project to be delayed or even cancelled, or may not have allowed for the funding of another important project. The resulting cost to the organization or to the public would be impossible to quantify precisely.

- No explicit motivation for urgency: Given all of the characteristics above, it is not surprising that a service process may be complex. Further, it is likely that most employees taking part in the process would not understand the entire process. In turn employees often cannot distinguish between critical and non-critical tasks. For example, consider an accountant needing data who leaves a voice mail on an architect's phone, where the architect is on a two week vacation. If would not be unusual for the accountant to move onto other tasks while waiting for the call back, causing a two-week delay.

When applying process improvement methods to a service, an analyst ignorant of these features may, for example, focus on speeding up paperwork when the main problem is inaccurate information being transmitted. Or, an administrator may use financial justification alone to decide on resource allocation to improvement projects. Finally, an administrator may populate a process improvement team without membership from all departments through which the process flows.

ORGANIZATIONAL CHARACTERISTICS

Based on the questionnaires and subsequent interviews, it is clear that barriers exist making the implementation of a process improvement program in the public sector particularly challenging. In fact, two types of barriers exist – those that could also exist in the private sector but appear with grater frequency in the public sector and those that are unique to the public sector. The following barriers are consistent with those found in the private sector:

- Inconsistent leadership motivation
- Management ignorance of process improvement methodologies
- Job security concerns
- Union rules and relations
- Employees without significant technical skill
- Many undocumented processes

These barriers are coupled with barriers that are unique to the public sector:

- A general skepticism of government (e.g., among politicians and the public)
- The civil service system (e.g., promotion policies that differ from the private sector)
- Legislative controls (e.g., laws, regulations, and ordinances)
- Competing special interests (e.g., land developers versus environmentalists)
- The election cycle and term limits (e.g., results in frequent leadership turnover)
- Revenue that is not directly linked to value (e.g., various taxes)

SUCCESS FACTORS

Process improvement projects have been performed across a range of government services, but long standing organizational-wide process improvement programs are rare. From the interviews and written questionnaires, certain common traits were noted for both individual improvement projects as well as in comprehensive programs. Analysis of these results uncovered key success factors.

Improvement Projects

Process improvement projects, even those projects undertaken in organizations that would not be considered progressive, possessed common characteristics. They employed a formalized project structure, similar to PDCA or DMAIC, at times with minor modifications. Survey and interview participates stressed the importance of a formal project structure, noting that it enhanced communication, made training easier, took subjectivity out of decisions, and allowed for a focus on root cause.

Successful projects tended to make use of basic problem solving and simple statistical methods. These methods included process mapping, standardization, affinity diagrams, five why's, mistake proofing, and Pareto analysis. Employing very basic methods would make sense for two reasons. First, compared to professional employees in manufacturing companies, public service workers lack significant technical ability. Second, in public sector service processes, there is currently a prevalence of "low hanging fruit."

Some examples of successful projects are summarized below:

- A City was able to lower average time of pot hole repair from four days to three hours, while keeping personnel levels constant. The project, initiated based on a large number of complaints, employed basic problem solving and analysis tools. Modifications to the service process included the re-scheduling and re-positing workers.

- A State systematically analyzed the reason for long queue times at driver's license renewal offices. At each location, teams were formed and data were collected to identify bottlenecks. By instituting self-service and re-organizing the facility layout, 50% or more reductions in queue time were achieved. Customer as well as employee satisfaction increased significantly.

- A City executed a project to reduce the high cost of replacing water mains. After mapping the process and analyzing the process maps, effective technological solutions were implemented. Costs decreased by 18% enabling more water mains to be replaced annually.

Organizational-Wide Programs

While many successful projects were highlighted, it was more difficult to find public sector entities with sustained process improvement programs. But certain common features were found in those organizations that have achieved some measure of success:

1. They created and continue to nurture a culture that fosters "process" oriented decisions rather than "blame" oriented decisions;

2. They initiated and continue to preach a constancy of purpose based on an underlying improvement methodology;

3. Their key leadership positions have been in place for a long period of time;

4. They have been motivated by leaders with experience in private sector quality management;

5. They started by setting up a full time position staffed by an experienced quality improvement manager, but considered this position temporary since the goal was to decentralize responsibility;

6. They make a pledge to employees that no one will lose their job as a consequence of an improvement project;

7. They stress internal communication of project results, often in a very visible way, such as story boards placed in a location frequented by many employees;

8. They continue to circumvent challenges and work to remove barriers; and

9. They measured the time to achieve stability in years.

Two differences were noted regarding how organizations approached process improvement: (a) while consideration is given to ensuring that project recommendations are successfully implemented, follow-up on projects in inconsistent or informal, and (b) while projects are initiated for logical reasons, few organizations appear to incorporate highly formalized or consistent project selection guidelines.

Examples cited earlier are revisited to illustrate how these common features are manifested in specific programs:

- In Fort Wayne, Indiana, the Mayor has been in place for eight years, having arrived with significant private sector experience. The program has included a program administrator who started full-time but who now dedicates less time to their Lean Six Sigma program. The program administrator is certified as a Master Black Belt and has been instrumental in

training about 130 employees as Black Belts or Green Belts. The Black Belts hold regular positions and devote just some of their time to improvement projects.

- At the Florida Department of Revenue, formalized training ensures just-in-time education. Each participant in a six-month training program attends classes one or two days each month while simultaneously working on an improvement project. They are placed on a team to define a real-world problem, collect data to validate the extent of the problem, analyze root causes, propose potential solutions, and present an action plan to the Department's senior leaders. After the course, they work to complete the action plan and report the results.

CONCLUSIONS

This research supports the notion that a process improvement program can find success in public sector organizations. It is clear, however, that many barriers present themselves. While challenges do exist, many dedicated individuals are attempting to initiate process improvement through individual projects. In fact, the Government division of the American Society for Quality includes about 1000 members. Among the myriad of advice offered by questionnaire participants and interviewees, no one suggested that implementing a comprehensive program for process improvement would be easy, but at the same time no one suggested that an effort not be made. By understanding the nature of services and by anticipating barriers, some programs have been successful. It is hoped that more public sector organizations will follow their lead.

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IMPROVING HEALTH CARE FORECASTING IN A NON-PROFIT ORGANIZATION USING QUANTITATIVE METHODS

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ABSTRACT

In an effort to improve forecasting accuracy in a publicly funded community health care organization, quantitative forecasting methods augmented by judgmental input were tested. This resulted in an improvement in forecasting accuracy, resulting in better allocation of funds and more clients being served.

INTRODUCTION

This paper examines the use of quantitative methods in the forecasting of service utilization levels in a non profit, publicly funded community health care setting; a Community Care Access Centre (CCAC) in Ontario, Canada. The issue for the CCAC is to be able to accurately forecast utilization of the services it provides, by month and by service, both at the beginning of the fiscal year to form the basis for a budget, and then throughout the year in order to re-allocate dollars between services and/or future months to meet changing demands and utilization patterns. Accurate forecasting thereby promotes optimal use of finite financial resources and increases the quality of medical care.

Forecasting presents a number of challenges in these types of organizations. [4] indicate that data can be incomplete or inconsistent in the health care industry due to the differing needs of the various departments generating or using the data. Further, the dynamic and constantly changing health care environment is a significant factor in the complexity of health care forecasting ([1],[2]). [5] point out that non profit organizations tend to be smaller, and that funds are often used for humanitarian purposes rather than improving operations. This has contributed to the limited body of knowledge in this sector. In addition, [3] identifies challenges unique to forecasting specifically within the service sector, such as the presence of multiple demand patterns (daily and monthly) and the influence of special events.

Community Care Access Centres (CCAC's) are non profit organizations funded 100% by the Ontario Ministry of Health and Long Term Care (MOHLTC). CCAC's arrange and authorize visiting health care services (the actual care is provided by other agencies, as approved by the CCAC) in homes and schools, coordinate placement to Long Term Care (LTC) facilities (i.e., nursing homes), and provide information about and make referrals to other community services. There are 42 CCAC's in Ontario, which provide a point of access to long-term care for more than 400,000 individuals each year. The CCAC examined in this study would be considered medium to large in size relative to other CCAC's, with a budget just over $50 million. Current forecasting methods are based primarily on the budgeting process. The annual budget for an upcoming year is developed internally, approved by the CCAC's Board of Directors, and then

approved by the MOHLTC. The budget attempts to allocate funds to the various services based on historical service utilization data and qualitative predictions of shifts in demand or need. The budget is then allocated per month and per service.

The specific project objectives are as follows:

1. Identify forecasting methods to be used in medium term forecasts (up to 12 months) that are more accurate at forecasting utilization than current CCAC forecasts.
2. Identify forecasting methods to be used in short term forecasts (one to two months) that are more accurate at forecasting utilization than the current CCAC forecasts.
3. Identify variables correlated with CCAC service utilization that will assist in understanding these relationships.

This project focuses on the CCAC services with the largest volume: Personal Support (PS), Nursing, Physiotherapy (PT) and Occupational Therapy (OT). PS is the provision of assistance to clients in the areas of primarily personal care (e.g. bathing, dressing, grooming, and exercise programs), caregiver relief and some housekeeping assistance. Nursing is provided by Registered Nurses or Registered Practical Nurses, who provide assessment, treatment and teaching in areas such as wound care, intravenous therapy, pain and symptom management, and peritoneal dialysis. PT provides intervention in the areas of exercise programs, safe walking and stair climbing, and pain management through modalities such as acupuncture. OT works with clients to promote independence in activities of daily living such as personal care or classroom activities. Nursing, PT and OT are provided in both homes and schools. A literature review is available from the authors.

METHODOLOGY

Both time series and regression analysis forecasting methods were examined for each of the four different services studied. The techniques were compared on the basis of Root Mean Square Error (RMSE), Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE). Time series methods examined for non seasonal data included: single moving average, double moving average, single exponential smoothing and double exponential smoothing. For data with seasonality, the seasonal additive, seasonal multiplicative, Holt-Winters additive, Holt-Winter's multiplicative and seasonal index methods were examined. The regression analysis began by consulting the CCAC to select independent variables. Stepwise, forward and backward regression models were all tested to determine which would provide the best forecast. Models were tested with all available data points, and also using a holdout period. Finally, a comparison was made with the CCAC's forecasted figures. Data for the dependent and independent variables was gathered from a number of sources at the CCAC.

ANALYSIS

Three stages of analysis were completed: critical events that could potentially be built into a forecasting model, correlation between variables to be used in developing a forecasting model

and finally, short and medium term forecasting models that may be better able to predict monthly service utilization than methods currently used by the CCAC.

Correlations between independent variables, dependent variables, and independent and dependent variables were calculated. Considering first correlations between independent variables, two variables were eliminated due to multicollinearity: Over 85, since it measures essentially the same thing as Over 75 and has lower correlation with the dependent variables, and CCAC Working Days, since it is similar to SP working days and has lower correlation with the dependent variables.

In examining correlation between dependent variables, two were significant: the correlation between OT and PT utilization is 0.746 and correlation between Nursing and PS is 0.360. This may not be directly helpful in forecasting as utilization data for one service is not available sooner than another. It may be helpful, though, in understanding CCAC utilization patterns (e.g., this CCAC often provides both OT and PT to clients recovering from orthopedic surgery.)

Finally, in examining independent variables that are correlated with service utilization, consider Table 1. Admit from Hospital is positively correlated with all services. This is a logical and intuitive result. Working days per month is positively correlated with all services except OT, with SP Working days having a higher correlation than CCAC Working Days. This is an interesting finding because CCAC Working days was actually used in the most recent fiscal year to help allocate the monthly budgets. This analysis suggests, however, that SP Working days should be used instead of CCAC working days. Also, as may be expected, the number of elderly clients (over 75 and Over 85) and Palliative Caseload are both positively correlated with PS utilization. Negative correlations (Wait for Placement and PS, Pediatric Caseload and OT and PT utilization) are unexpected, possibly not indicative of true relationships but instead may indicate unrelated co-movement.

Table 1: Correlation between Dependent and Independent Variables*

	PS Utilization	Nursing Utilization	PT Utilization	OT Utilization
# CCAC Working Days in the month	***0.397***	***0.358***	***0.316***	0.073
# Service Provider Working Days / month	***0.484***	**0.481**	***0.325***	0.103
# Clients Over 85	***0.540***	0.128	-0.023	0.029
# Clients Over 75	***0.572***	0.117	0.116	0.188
# Clients Admitted from Hospital to CCAC	***0.651***	***0.333***	***0.308***	***0.390***
# Clients Waiting for Placement in a Long Term Care Facility	***-0.603***	0.134	-0.085	-0.273
Current Total Caseload (# clients)	-0.114	0.249	-0.236	-0.177
Palliative Caseload	***0.336***	0.115	-0.072	0.072
Pediatric Caseload	0.060	-0.101	***-0.413***	***-0.603***

* bolded values are statistically significant, alpha 0.05; full variable definitions available from the authors

Of interest, as well, were variables that were *not* correlated with service utilization. Palliative and Pediatric Caseload were not correlated with Nursing as one might expect. A change in the palliative population is frequently provided as an explanatory factor when nursing and PS utilization increases but this has never been supported by more than anecdotal information. In addition, the number of elderly clients receiving service did not correlate with Nursing, OT or PT utilization. Thus, this anecdotal information appears to be incorrect, especially when allocating nursing budgets.

Finally, note that it was initially felt that lagging some of the variables may provide stronger correlations. However, this had very little effect and did not improve the forecasts.

Forecasting Models

The PS data has a distinct upward trend over the 3 year period. There does not appear to be a seasonal pattern. Single exponential smoothing with an alpha value of 0.205 was identified as the most accurate time series forecasting method. This method had a MAPE of 4.4%. Thus, the quantitative method outperformed the budgeting method by 2.25% (representing an improvement of $35,772 CD, which is 2.67% of the average monthly budget). (R-squared values and all error measures are available for all the analyses from the authors.)

The best model overall was achieved using backwards regression with the independent variables of SP Working Days, Palliative Caseload and the Dummy Variable (Trend). The adjusted R-squared was 0.5564 with no holdout data and 0.6151 with holdout. Forecast accuracy was 3.5% better than the CCAC forecast, representing an improvement of $52,782 per month.

For nursing, a double moving average model with 9 periods and deseasonalized data provided the lowest MAPE (3.47%). This is 4.34% better than the CCAC forecast, representing a monthly improvement of $43,291. Stepwise, forward and backward regression methods all identified the same model with the independent variables of SP Working Days and Dummy Variable (SI). The adjusted R-squared was 0.4968 with no holdout data and 0.5150 with holdout. With a MAPE of 3.71% for regression with no holdout, the regression was not able to forecast with greater accuracy than the time series method, although it performed better than the CCAC forecast.

In physiotherapy, the best model was achieved using backwards regression and included the independent variables of Admit from Hospital, Dummy Variable (SI), SP Working Days and Wait for Placement. The adjusted R-squared was 0.6913 with no holdout, and a MAPE of 5.26%. The adjusted R-squared was 0.7270 with holdout. Note that this regression model slightly outperforms the best time series model, and that both outperformed the CCAC forecast. The regression model performed 2.43% better based on MAPE, which represents $2,581 per month.

For occupational therapy, the double moving average with 7 periods and deseasonalized data provided the most accurate time series forecast, with a MAPE of 3.71%. This is 10.03% better than the CCAC budget, or $18,019 per month. The model selected through regression methods included the independent variables of Dummy Variable (SI), Current Total Caseload and Over 75. The adjusted R- squared value was 0.8945 with no holdout data and 0.8746 with holdout data. The MAPE was 4.37% with no holdout data; less accurate than the best time series method but more accurate than the CCAC budget.

CONCLUSIONS

The purpose of this paper was to determine whether the application of quantitative methods can improve forecast accuracy for service utilization levels in a non profit, publicly funded community health care setting. Accurate forecasting is important as decisions impacting services available to clients are based on these projections. Specific to the CCAC, the purpose was to identify short and medium term forecasting quantitative methods, with judgment as an input to model development, that are more accurate than the CCAC's current forecasting methods.

Table 2 summarizes the forecasting methods recommended for both short and medium term horizons for the four services studied. The choice of short term methods is based on the analysis above; the choice of medium-term methods is based on the above, and the timing of the availability of data was also considered. The time series and regression models recommended for short term forecasting cannot forecast more than one month into the future because of the lack of data availability. As an example, the nursing utilization forecast for the full 12 months of the CCAC fiscal year of April 2006 to March 2007 cannot be made on April 1, 2006 using the recommended short term method because actual data from directly preceding months is required (e.g., for Nursing, it requires 9 prior months) to make accurate monthly forecasts. Therefore, the best possible models were selected for medium term forecasts using only data that would be available at the beginning of the medium term forecast horizon. Then, regressions were re-run with only data available at the beginning of the year in order to determine the best model. For example, the short term model for Physiotherapy includes two variables available at the beginning of the year (Dummy Variable (SI) and SP Working Days), but using only the Dummy Variable results in a slightly higher adjusted R^2 than when both are used. Thus, medium term forecasts in Table 2 are all regression-based, and all include only variables that are available a year in advance. The average loss in adjusted R^2 for the medium term models is only 0.45%.

Table 2 – Recommended Forecasting Methods

	Short Term	Medium Term
Personal Support	Multiple regression with Dummy Variable (trend), Palliative Caseload and SP Working Days	Multiple regression with Dummy Variable (trend) and SP Working Days
Nursing	Double moving averages (9 periods) with deseasonalized data	Multiple regression with Dummy Variable (SI) and SP Working Days
Physiotherapy	Regression with Dummy Variable (SI), Admit from Hospital, SP Working Days, Wait for Placement	Regression with Dummy Variable (SI)*
Occupational Therapy	Double moving averages (7 periods) with deseasonalized data	Regression with Dummy Variable (SI)

* higher R^2 than with both SP working days and the Dummy Variable (SI).

Short term and medium term methods recommended in Table 2 are all able to forecast with greater accuracy than CCAC's current methods (4.04% on average) even when forecasting at

least 8 months into the future. For instance, the short term forecast for one service, Occupational Therapy, showed an improvement in MAD of 211 visits per month. Thus, better forecasting would have a significant client impact; these 211 visits represent service to approximately 132 individuals in a month (a 9.67% improvement in the number of individuals served).

Analysis of correlation coefficients was helpful in identifying variables that were correlated and also those that were not correlated with service utilization. This can assist the CCAC when trying to understand changes in utilization patterns. For example, partly as a result of this research, referrals from the local hospitals are now tracked and monitored by the CCAC on a monthly basis and are used for service utilization analysis. Palliative caseload need not be examined when nursing utilization changes unexpectedly as it is not significantly correlated. The high correlation between Occupational Therapy and Physiotherapy utilization found in this research highlighted the need to analyze the number of referrals made simultaneously for both Occupational Therapy and Physiotherapy for one client. This has led to policy changes to better allocate rehabilitation services. Further, discussion with the CCAC identified areas where the CCAC may collect data that could be used in regression analysis in the future. For example, a Case Mix Index (a system that places clients into distinct service-use/intensity categories based on a standardized client assessment tool) for current long term CCAC clients is being examined to see if there is a relationship to monthly service utilization data.

This project has demonstrated that quantitative forecasting methods, with judgment as an input to model development, can assist non profit organizations that operate in the complex and changing health care environment. Quantitative methods can also assist health care organizations in understanding utilization patterns and underlying factors that may impact utilization levels. Further work may assist in identifying more accurately the drivers of health services utilization, reducing reliance on historical trends. In the future, this could potentially lead to more accurate forecasting methods that consider the dynamic nature of health care.

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SUBJECTIVE WELL-BEING AND HEALTH STATUS: A CROSS COUNTRY STUDY

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ABSTRACT

The purpose of this paper is to examine the influence of subjective well-being (SWB) on health status represented by life expectancy at birth, expected lost healthy life at birth, and rates of hospital discharges for all causes in 24 countries belonging to the Organisation for Economic Co-operation and Development (OECD). SWB is measured in terms of life satisfaction, pleasant affect and unpleasant affect. Univariate analysis indicates that life satisfaction impacts life expectancy positively and expected lost healthy life years at birth negatively. On the other hand, unpleasant affect tends to decrease life expectancy and increase expected lost healthy life years. According to the Spearman rank correlations, pleasant affect does not have any influence on any health status indicators. In addition, according to multiple linear regression analysis, only unpleasant affect has an impact on life expectancy and no other SWB indicators have any statistically significant influence on any health status indicators. The adverse impact of unpleasant affect and a lack of any influence of pleasant affect on health status indicate that social indicators measuring SWB with the impact on health should put higher emphasis on unpleasant affect.

INTRODUCTION

Subjective well-being (SWB) measures people's appraisal of their lives. Even though, per capita gross domestic product, crime rates, and pollution can provide some idea about quality of life of a country, these measures fail to provide any indication about happiness of a society. People evaluate their lives whether they are meaningful, satisfying, and fulfilling. They also appraise their life in terms of major events in their life. They react positively when things go well in life and negatively when things go badly. The moods and emotions or affects are pleasant when things go favorably and unpleasant when things go adversely. The affect represents an evaluation of life. More people feel pleasant affects then more people are appraising their lives positively. The subjective well-being is a proxy for people's aggregate evaluation of their lives. In short, SWB is a proxy for "life satisfaction", "subjective quality of life", or "happiness" of a country. Even though SWB is subjective and may be perceived differently by different people, SWB of a country can be measured through national surveys, daily experience sampling, and experiments. (Heylighen and Bernheim, 2001).

In recent years, considerable progress has been made in measuring SWB. SWB has been measured using both affective and cognitive components. The affective component is represented by pleasant affect and unpleasant affect and their differences. The cognitive component is represented by individual's life satisfaction (Diener et. al 1999). Even though, pleasant affect and unpleasant affect can be considered as a single dimension with opposite polarity, research indicates that they are two dominant and separate independent dimensions of affect. Pleasant affect represents degree to which an individual feels active, alert and enthusiastic, and unpleasant affect represents degree to which an individual feels guilt, anger, and fear. Low pleasant affect is accompanied by dullness and lethargy and low unpleasant affect calmness and serenity. (Warr, Barter, and Brownbridge 1983; Watson and Tellegen 1985). Although affective and cognitive dimensions of SWB are separate, they are interrelated. Therefore, Kozma(1996)

proposes existence of higher order construct of SWB. SWB's vary significantly across countries. SWB of a country is positively related to its per capita gross domestic product. However, the reasons for this association are not well understood. It could be for any reason that is related to the attributes of rich countries such as human rights, equality, individualism, political stability, interpersonal trust and so on (Diener and Suh, 1997).

The purpose of this paper is to examine the influence of SWB on physical wellbeing or health. In this paper, we measure health in terms of life expectancy, expectation of lost healthy years at birth, and hospital discharge rates for all causes for 24 countries belonging to Organisation for Economic Co-operation and Development. This paper is organized into five sections. In the next section, we briefly review literature. We then present methodology followed by analysis of results. We close this paper with conclusions.

REVIEW OF LITERATURE

Ruut Veenhoven (1991, 1994, 1995, 1996a, b) provides an extensive review of SWB. Diener and Suh (1997), Diener, Suh, and Oishi (1997), and Inglehart and Klingemann (2000) examine influence of age, status, gender, health, and personality on SWB. Some general findings include younger and older people are happier than middle aged people, women have more positive attitude towards their life than men, and employees earning high income are happier than employees earning low income. Veenhoven (1994) finds that average SWB is positively related to socioeconomic indicators such as GNP per capita, average education level, freedom of expression and so on. According to Lucas and Diener (1998), SWB is more influenced by rates than intensity of pleasant affect. In addition, people who experience intense pleasant affect also experience intense unpleasant affect and vice versa (Diener and Lucas, 2000). Zautra (1991) found similar relationship for rates of pleasant affect and unpleasant affect.

Average SWB is also found to be correlated with health. Grossarth-Maticek and Eyesnck (1995) argue that because healthy people are more comfortable, they enjoy life more. Similarly people who feel bad are likely to feel unhealthy because of chronic stress through such mechanism as increased cortisol levels. Veenhoven(1996a, b) does find strong correlation between life expectancy and child mortality and life satisfaction. However, these studies should be viewed cautiously. Some studies use weighted average of responses as a measure of happiness. Others use proportions of responses higher than certain values. In addition, some conclusions are based on univariate analysis. Most studies only include satisfaction of life as a proxy for SWB. However, the analysis performed in this paper include measures of SWB that include people's moods and emotions called affect in addition to general satisfaction with their life.

METHODOLOGY

There are several surveys that measured SWB of countries conducted from 1946 (See Cantril, 1965; Inglehart et al. 1998). In addition, Michalos(1991) have done surveys of college students. Veenhoven(1993) presents a summary of results of 916 national surveys on SWB. We use mean levels of SWB estimated from responses to the World Value Survey II. SWB is measured in terms of life satisfaction, pleasant affect, and unpleasant affect. The SWB data is from Diener and Suh (1997). Since most people feel higher frequencies of pleasant affect than unpleasant affect, higher values of indicators denote that people in some countries are happier than people in other countries.

Table 1: Descriptive Statistics (Number of observations 24)

Variable	Average	Max	Min
Life Satisfaction	7.369	6.03	8.39
Hedonic Balance	1.487	0.39	2.90
Pleasant Affect	2.568	1.12	3.63
Unpleasant Affect	1.079	0.24	2.50
Life Expectancy at Birth	77.179	68.10	81.20
Healthy Life Expectancy at Birth	68.396	58.70	73.80
Expected Lost Healthy Life at Birth	8.783	7.40	12.00
Physicians per 1000 Population	2.875	1.30	4.10
% Daily Smokers, 15 Years and Over	27.621	18.90	47.00
% BMI over 30	12.552	2.90	30.90
GDP Per Capita $	20965.920	2954.00	37531.00
Hospital Discharge Rate per 100,000 Population	15312.270	4038.00	28442.00
GINI Coefficient	31.174	23.10	51.90

We use life expectancy at birth, expected lost healthy years at birth, and hospital discharge rates for all causes, all for years 2000, as indictors of health status. Life expectancy at birth represents one of the most frequently used measures of health status. Expected lost health years at birth represent difference between life expectancy at birth and healthy life expectancy at birth. Healthy life expectancy measures the number of years lived in what might be called "full health." Healthy life expectancy is estimated by weighing the years of ill-health according to severity and subtracting them from overall life expectancy. Therefore, expected lost healthy years at birth gives a measure of ill health in the society. Hospital discharge rate provides a measure of serious illnesses in the society. Health data is from OECD Health 2000.

ANALYSIS OF RESULTS

Univariate Analysis

In this paper, we examine the influence of SWB on health status of 24 countries belonging to the Organisation for Economic Co-operation and Development (OECD). We represent SWB by life satisfaction, pleasant affect, and unpleasant affect. Health status is denoted by life expectancy at birth, lost expectancy of healthy life at birth, and hospital discharge rates per 100,000 population for all causes.

In Table 1, we present descriptive statistics of various variables used in this paper. In Table 2, we present the Spearman rank correlation between SWB variables and health variables. We discuss associations that are statistically significant at the 0.05 level. We first discuss associations between health status indicators. Life expectancy is negatively associated with expected lost healthy life at birth. This indicates that countries with high life expectancy at birth tend to have lower expected lost healthy life. Hospital discharge rates, on the other hand, are related to neither life expectancy nor lost healthy life. The Spearman rank correlations among SWB measures indicate that life satisfaction is positively related to pleasant affect. Pleasant affect is positively associated with unpleasant affect. This indicates that countries with frequent pleasant feelings also have frequent unpleasant feelings. However, this

Table 2: The Spearman Correlations Between Health Status and Various Variables.

Variables	Life Expectancy	Lost Healthy Life	Hospital Discharges	Life Satisfaction	Pleasant Affect	Unpleasant Affect
Life Expectancy	1***	-0.566***	0.111	0.462**	-0.027	-0.654***
Expected Lost Healthy Life at Birth	-0.57***	1.000***	-0.262	-0.457**	0.044	0.506**
Hospital Discharges per 100,000 People	0.111	-0.262	1.000***	-0.003	-0.151	-0.075
Life Satisfaction	0.46**	-0.457**	-0.003	1.000	0.482**	-0.320
Pleasant Affect	-0.027	0.044	-0.151	0.482**	1.000***	0.392*
Unpleasant Affect	-0.65***	0.506**	-0.075	-0.320	0.392*	1.000***
Physicians per 1000 People	0.28	-0.181	0.495**	0.183	-0.301	-0.496**
% Smokers	-0.01	-0.340	-0.147	-0.161	-0.399*	-0.103
% BMI>30	-0.576***	0.665***	-0.291	-0.189	0.238	0.582***
GDP Per Capita	0.625***	-0.669***	0.072	0.679***	0.226	-0.436**
GINI Coefficient	-0.248	0.224	-0.665***	-0.008	0.207	0.358*

relationship is statistically significant only at 0.1 level. This is consistent with the finding of Zautra (1991).

Life satisfaction has a positive influence on life expectancy and negative influence on expected lost healthy life at birth. Unpleasant affect has negative influence on life expectancy at birth and positive influence on expected lost healthy life at birth. However, pleasant affect is not related to any of the health status variable. We can therefore infer that negative feelings have more adverse impact on health status than positive impact that pleasant feelings may have on health status.

Smoking is a leading cause of death. It is a largest avoidable risk causing cancers and circulatory diseases. According to Or(2000) smoking increases premature mortality after controlling variables such as occupation, GDP per capita and health expenditures per capita. However, univariate analysis does not find any associations between percent of smokers in a country and health status and SWB of its people. However, there is a slight negative link between percent of smokers and pleasant affect (level of significance 0.10).

Obesity represented by percent of people over 15 years of age with body mass index (BMI) over 30 is related positively to unpleasant affect. This indicates that countries with high obese people have people with high unpleasant affect. Obesity also adversely affects health status by reducing life expectancy and increase expected lost healthy life at birth.

The Gini coefficient is a proxy for income distribution. The Gini coefficient is 0 when every one has equal incomes and 1 if only one person has all the income and others none. In other words, 1 represents

a perfect inequality and 0 perfect equality. Therefore, higher is the Gini coefficient, higher is the inequality. High income disparities are found to have positive relationship with hospital discharges.

GDP per capita is a major determinant of health status. Higher per capita incomes help to increase resources needed for health delivery system. According Or(2000), a 10 percent increase in GDP per capita can reduce premature mortality by 3.5 to 4.5 percent after keeping all other variables constant. The Spearman rank correlations indicate that higher GDP per capita is associated with higher life expectancy at birth and lower expected lost healthy life at birth.

Physicians represent a major resource that significantly influences health status. Physicians per capita has a major impact on the health expenditures and outcomes. According to Grubaugh and Santerre (1994), physicians per capita is negatively related to mortality rates after accounting for other variables. The Spearman rank correlations indicate that physicians per 1000 people is positively associated with hospital discharges for all causes per 100,000 people.

Multivariate Analysis

Since univariate analysis does not take into account impact of other variables, we perform multivariate analysis using multiple linear regression analysis. We use life expectancy at birth as a dependent variable and SWB and socio-economic variables as independent variables. Multiple linear regression results are as follows:

Life Expectancy =	77.79	+0.0001 GDP Per Capita	-0.07 Life Satisfaction
	(12.3***)	(3.3***)	(0.07)
		+0.19 Positive Affect	-3.39 Negative Affect
		(0.23)	(2.5**)

R-squared=0.73, R-squared(adj)=0.68, F-ratio=13.09***, DW=2.2, # of observations= 24

Multiple linear regression analysis indicates that GDP per capita is positively related to life expectancy. Life satisfaction and positive affect do not have statistically significant (at 0.05 level) influence on life expectancy. However, negative affect, reflecting negative feelings and emotions, have adverse impact on life expectancy.

The multiple linear regression results with expected lost healthy life at birth are as follows:

Expected Healthy Lost Life=	15.1	-0.0001GDP Per Capita	+0.057 obesity
	(4.84***)	(2.82**)	(1.7*)
	-0.83 life satisfaction	+0.54 Positive Affect	-0.95 Negative Affect
	(1.8*)	(1.28)	(0.90)

R-squared=0.68; R-squared(adj)=0.58; F-Ratio=7.46***; DW=1.81; # of observations=24

According to the regression analysis, higher GDP per capita and life satisfaction are associated with lower ill health and obesity with higher ill health. Positive and negative affects do not have any statistically significant at the 0.05 level on expected lost healthy life at birth.

The multiple linear regression results with logarithm of discharge rates per 100,000 people are as follows:

Log (Discharge Rate) = 4.83 -0.021 Gini Coefficient +0.091 Physicians per 1000 people
(8.6***) (3.8***) (1.74)
-0.08 Life Satisfaction+0.091 Pleasant Affect+0.041 Unpleasant Affect
(1.0) (1.1) (0.35)
R-squared=0.72; R-squared(adj)=0.62; F-Ratio=7.53***; DW=1.56; # of observations=21

According to the regression analysis, SWB indicators have no statistically significant (at the 0.05 level) influence on the hospital discharge rates. The Gini coefficient that represents income disparity negatively impacts hospital discharge rates.

There is no consensus whether pleasant and unpleasant affect represent a single dimension or two independent dimensions (See Diener and Lucas, 2000 for more discussion). Our analysis shows that pleasant affect has no statistically significant influence on health status and unpleasant affect has adverse impacts on life expectancy at birth and expected loss of healthy life at birth. From this, we can infer that pleasant and unpleasant affect are more likely to represent two independent dimensions.

CONCLUSIONS

In this paper, we examine the influence of SWB on health status. The Spearman rank correlation indicates that high life satisfaction increases life expectancy and decreases expected lost healthy life at birth. On the other hand, unpleasant affect decreases life expectancy and increases expected lost healthy life. However, univariate analysis does not find any impact of pleasant affect on any health status indicators. In addition, according to multiple linear regression analysis, only unpleasant affect have impact on life expectancy and no other SWB indicators have any influence on health status indicators. Therefore, any country trying to increase health status should consider how to reduce unpleasant affect on its people.

[References available from the Author]

WIRELESS NETWORK SECURITY IN HOSPITALS: A CONCEPTUAL FRAMEWORK AND RESEARCH PROSPECTUS

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ABSTRACT

A steep increase in the adoption of wireless technologies in healthcare organizations has been observed globally over the past few years. Among such technologies wireless LANs (WLAN) are deployed in hopes of reaping the many benefits. However, hospitals that implement WLAN have to deal with a host of risks that accompany the anticipated benefits. We note that facilitation, inhibition, risk and benefit factors can be identified in the literature with regard to implementing WLAN in healthcare settings. In this paper, we report the current progress of an ongoing research project that investigates such factors. The research model was developed based on a thorough study of the relevant literature as well as observations of the industry practices. A survey was administered to gather responses from the CIOs of leading U.S. hospitals chosen from the list of Best Hospitals according to *U.S. News and World Report*. The project is at its data analysis stage.

Keywords: Wireless Local Area Networks (WLAN), Hospitals, Network Security, WLAN Adoption Factors, Chief Information Officer (CIO).

INTRODUCTION

Hospitals across the globe have begun to leave their traditional paper-based recordkeeping systems for adopting the wireless local area network (WLAN) technology in hopes of reaping the many benefits. Paper-based recordkeeping systems in hospitals are not only tedious, but also inefficient, inaccurate, and incomplete. At times, employees have difficulty locating a patient's chart and when they do find it, the chart is often missing reports and other valuable data. Additionally, much of the recordkeeping process is redundant, and handwriting in the chart is often illegible. A recent report of the Institute of Medicine estimates that 98,000 patients die annually as a result of preventable medical errors and 13% of the errors are due to poor handwriting (Rhoads, 2004).

The various pros and cons of WLAN notwithstanding, many factors contribute to this global movement but much more has to be learned as to what drivers are behind it and what actual and perceived risks and benefits are noted by the decision makers. In addition, what measures are available to overcome the weakest spot of the current technology, namely network security, begs for more up-to-date information, and how they are actually implemented in the field has yet to be investigated.

The main contribution of this paper is two-fold. First, we identify the two dimensions of the factors that can explain this worldwide phenomenon of WLAN adoption, and accordingly propose taxonomy of the factors based on the dimensions. These factors result from a thorough review of literature as well as close observations of the practices in the healthcare industry. Second, through a survey of CIOs in leading U.S. hospitals according to the list published by *U.S. News and World Report*, we provide a model of how these factors contribute to actually securing the network resources in the many hospitals.

The remainder of this paper is organized in the following manner. The next section presents the taxonomy of WLAN adoption factors along with the relevant literature, in an abridged format. Then follows is a discussion on the corrective measures of the WLAN security threats, also in an abridged format. In the methodology section, we describe our research model and the survey design. Since the project is at its data analysis stage, we will forego discussions about the result of data analysis, or its implications, at this time.

TAXONOMY OF WIRELESS LAN ADOPTION FACTORS

Evidence abounds in the literature that points to the reasons why hospitals adopt WLAN or why not. These factors can be organized along the dimension of "drivers" for which some are considered drivers of facilitation while others are drivers of inhibition. While these driver factors are based primarily on the factual understanding of WLAN technology, the same factors can be organized along another dimension, namely the "perception" dimension. Certain factors are regarded as benefits while other are associated with risks. Figure 1 below depicts the taxonomical scheme, in which four categories of WLAN adoption factors are identified. Category I factors can take the designation of "facilitating factors due to perceived benefits," while Category II factors are "inhibiting factors in spite of perceived benefits." and so forth.

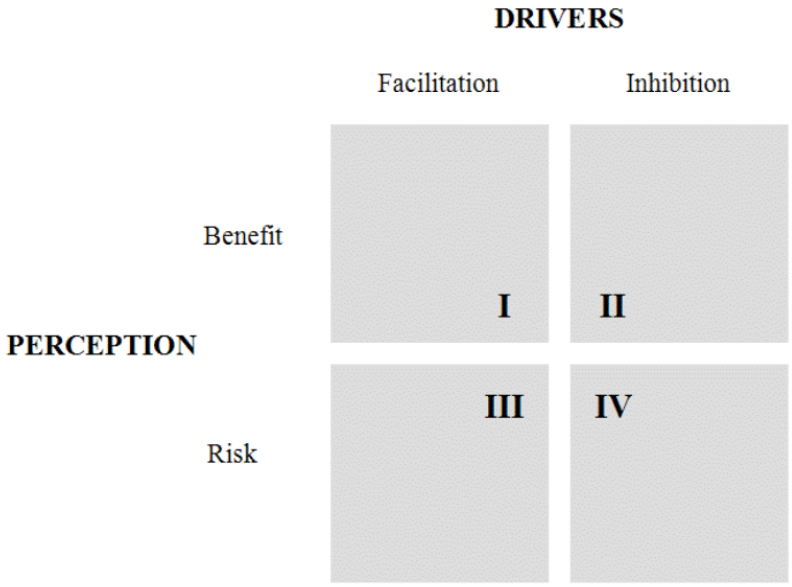

Figure 1. Taxonomy of WLAN Adoption Factors

The above taxonomy produces the following four categories of WLAN adoption factors:

(i) facilitating factors due to perceived benefits;
(ii) inhibiting factors in spite of perceived benefits;
(iii) facilitating factors in spite of perceived risks; and
(iv) inhibiting factors due to perceived risks.

These factors are summarized in Table 1 along with their characteristics and references.

Table 1. Summary of WLAN Adoption Factors

Adoption Factors	References
I. Facilitating factors due to perceived benefits	
• to gain competitive advantage	Rhoads (2004)
• improved, more accurate, and more complete patient recordkeeping leading to the improvement of healthcare provided	Rhoads (2004)
• wireless technology does not inhibit the mobility, speed, or flexibility that healthcare professionals require	Andrade, von Wangenheim, Bortoluzzi, & De Biasi (2003); Oyama, Tannas, & Moulton (2002)
• patient information is retrieved at a much faster rate, leading to quicker and more accurate diagnosis and decreased mortality rates	Siika et al. (2005); Anantharaman & Han (2001); Clemmensen et al. (2004)
• faster and more comprehensive data repositories for health systems with multiple hospitals	McDonald et al. (1999)
• increased patient comfort levels	Catrysse et al. (2004)
• reduction in time that personnel has to devote to redundant and monotonous tasks	Catrysse et al. (2004)
II. Inhibiting factors in spite of perceived benefits	
• to hire specialized network managers	Derived from Coursaris, Hassanein, & Head (2003)
• downtime for infrastructure change	Derived from Coursaris, Hassanein, & Head (2003)
• high start-up costs including overcoming infrastructure limitations	Frolick and Chen (2004); Ware (2002)
• to combat the "culture of resistance"	King (2005)
• JCAHO and HIPAA regulations for wireless technology implementations	Lafrance (1995)
III. Facilitating factors in spite of perceived risks	
• illegible handwriting in patients' charts	Rhoads (2004)
• time spent completing paper work	Frolick & Chen (2004); Maffeo (1999)
• billing cycle	Gillette (2005)
• cost of health information management	Briggs (2004)
• attracting qualified personnel	Briggs (2004)
IV. Inhibiting factors due to perceived risks	
• lack of security due to the nature of wireless technology	Frolick & Chen (2004); Ware (2002); Songini (2000)
• unproven benefits / ROI	Frolick & Chen (2004); Ware (2002)
• high start-up costs and overcoming infrastructure obstacles	Frolick & Chen (2004); Ware (2002)
• constant threat of new viruses and intruders	Mehta (2004); Fitzgerald & Dennis (2005)
• patient data could be intercepted, viewed, or worse yet, altered	Mehta (2004); Fitzgerald & Dennis (2005)
• wireless devices could be stolen	Frolick & Chen (2004)

SECURITY MEASURES FOR WIRELESS LAN

Hospitals can enjoy the many benefits of wireless technology, but they first must address the security concerns inherent in WLANs. One simple step that a hospital's computer professionals can do to keep out casual intruders, but often forget about, is to make certain that the security features on its wireless products are enabled to activate three levels of security: Service Set Identification (SSID), Media Access Control (MAC) Addressing, and Wired Equivalent Privacy (WEP) (Campbell & Durigon, 2003). Additionally, network managers should keep hardware and software, especially antivirus software, as well as patches on access points and clients up to date.

However, this will not stop expert or professional hackers. The literature suggests that hospitals adopt a virtual private network (VPN) to secure a virtual tunnel between the hospital's network and the user (Campbell & Durigon, 2003). Also, the literature recommends that hospitals use firewalls to make their network appear invisible to the Internet and that hospitals implement RADIUS or Kerberos technologies for user identification and authentication (Campbell & Durigon, 2003). Lastly, hospital networks should most certainly employ some form of encryption to disguise information, preferably Public Key Infrastructure (PKI). PKI is one of the most secure encryption techniques available with longer keys and a reduced key management problem.

Many technology firms have begun to offer hardware and software that allow hospitals to block, track, and eliminate unauthorized network users (Rockwell, 2004). One such company, AirDefense, offers products that allow hospital network managers to protect their network by tracking and terminating intruders' access of the network through its use of remote sensors that monitor devices. Authorized users receive one type of tag and unauthorized users receive a different tag, which enables a hospital's computer professionals to monitor their network carefully. With AirDefense technology, hospitals can be sure that only authorized users are accessing their network.

BAE Systems offers technology that inhibits Wireless Fidelity (Wi-Fi) signals from escaping the facility (Rockwell 2004). By strictly limiting Wi-Fi signals to inside a hospital building, BAE's technology is truly revolutionary as it offers a sound solution to wardriving. Two other companies that offer security solutions to hospitals are "AirMagnet, which produces WLAN management systems and Newbury Networks, which offers Wi-Fi monitoring systems that detect and limit access to facilities" (Rockwell, 2004, p.20).

As mentioned earlier, hospitals must still contend with the fact that some wireless devices can be stolen just as easily as a physical patient chart. One way hospitals have decided to alleviate the effect of such an act of thievery is to store all of the data form its wireless devices onto a central server. For example, Hackensack University Medical Center (HUMC) in New Jersey has recently begun using the Citrix MetaFrame Presentation Server to separate the application's logic from its interface, centralizing installation, processing, administration and deployment on the server (Communications News, 2004). Hence, if the wireless device (a thin client) were stolen, the data would be safe; however, the hospital would still incur a loss due to the theft. Furthermore, the hospital must make sure that the centralized computer is well secured and that the data stored there is backed up.

Besides taking steps to prevent external intruders, hospitals must also take steps to prevent internal intruders. Research indicates that approximately 70% of security breaches result from internal sources, both intentional and unintentional (Shaw, 2003). There are many areas that hospitals can address to

ensure they do not ignore securing the interior. First, they can implement automatic log-off features (Doherty, 2004). If an employee has not used the computer after so many minutes, the computer should be programmed to log off that person automatically to prevent unauthorized users from accessing the network. Another action hospitals can take is to split their networks into two segments: public and private (McGee, 2004). The public network could be used for patient and visitor internet surfing, while the private network could be restricted to hospital employees' interaction with patient data.

Additionally, Mark Tuomenoksa, founder and chairman of OpenResearch Inc., proposes that in order to secure the interior of a network, a hospital should have the "triple A's" in place: authentication, authorization, and accounting (Rogoski, 2002). The hospital must be certain that the person logging on is not only who he claims to be (authentication), but also that he has access to programs related only to his job (authorization) (Rogoski, 2002). For example, a candy striper should be permitted to check her hospital email account; however, that person should not have access to patients' medical records. Furthermore, hospitals should make sure their WLAN provides an audit trail or record of who is connected (accounting). Keeping a thorough record of employee activity provides an extra security feature that catches possible intruders and allows hospital administrators to react accordingly.

Furthermore, hospital employees are notorious for leaving post-it notes on their computer screens that list their usernames and passwords because they need to remember so many (Walker 2000). This is something that hospitals can address immediately by informing their employees that they are no longer permitted do that. As a more permanent and effective solution to this obstacle, many hospitals, such as St. Luke's Episcopal Hospital in Houston, have initiated a Personal Authentication Infrastructure (PAI), a combination of smart cards and biometrics (Walker, 2000). Users swipe a smart card identification badge and then place a finger on a fingerprint recognition device to access computer systems. PAI programs are not only convenient, but they also encompass the triple A's that Tuomenoksa suggests be in place.

In addition to providing an extra security feature, a simplified log on system will save the hospital a great deal of money because the industry reports that resetting passwords can cost up to $340 per user (Walker, 2000). Without this worry, a hospital's IT department can focus its energies on more relevant tasks that add value to the hospital, such as researching and employing new security technology.

As WLANs become more popular in hospital settings, the need for security intensifies. Without a doubt, hospitals will further improve upon user authentication and authorization. Hospitals will continue to experiment with the ideas of single sign on via a biometrics and smart card combination. However, biometrics is by no means a perfect solution and intruders are always looking for ways to beat the system. For example, one man used a fingerprint embedded into a gel to trick the senor into believing it was a real finger (Rogoski, 2002). In the future, hospitals will most likely test other forms of biometrics including iris scans and voice recognition.

Finally, hospitals will continue to experiment with stronger encryption techniques that use longer keys as well as keeping up with the latest firewall and antivirus software. Several hospitals are looking to adopt IEEE 802.11i and 802.1x because of the security standards that come with the technology. Also, the wireless devices used in hospitals will continue to evolve. Currently, physicians use tablet PCs and PDAs. In the future, it is expected that more hospital personnel will begin to use smart phones, cell phones that not only allow them to converse with colleagues, but also allow them to view and enter patient data (Schuerenberg, 2004).

RESEARCH MODEL AND METHODOLOGY

Based on the taxonomy of WLAN adoption factors, we conjecture that the categories of factors differently contribute to the adoption or non-adoption of WLAN in hospitals. We also assert that the hospital IT executives' perceptions and their actual implementation of corrective measures to counter the network security risks are dictated by the different categories of WLAN adoption factors. Figure 2 below shows the research model.

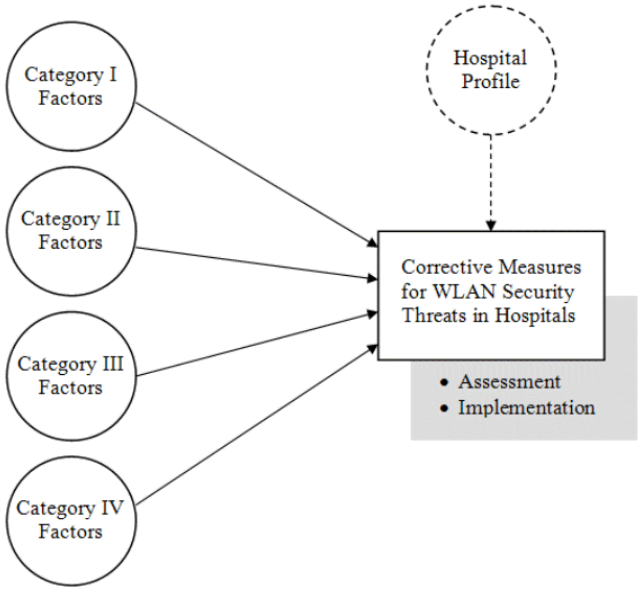

Figure 2. Research Model

To this end, a survey instrument was developed, which reflects the discussions in the preceding sections. Subsequently, the survey questionnaires were administered to CIOs and other top IT executives of 200 hospitals, selected from the list of "Best U.S. Hospitals" recently published in *U.S. News and World Report*. At the time of the submission of the current manuscript, the response rate reached 28%, and the data analysis has just begun. Detailed discussions and managerial implications are forthcoming.

REFERENCES

The references sited in this paper will be made available upon request. Please contact either author.

COMPETING VALUES IN HEATH CARE: BALANCING THE (UN)BALANCED SCORECARD

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ABSTRACT

Health care organizations, facing complex environments driven by two decades of dramatic change, are adopting new strategic frameworks such as the Balanced Scorecard (BSC). While the BSC appears to provide a valid approach to strategic planning, it omits the key perspective of employees and emphasizes making tradeoffs so the approach is likely to encourage an organizational culture that undervalues and overworks employees, resulting in reduced quality and increased costs in the long run. To address this limitation, we propose using the Competing Values Framework (CVF) (Quinn and Rohrbaugh, 1983; Quinn, 1988) either on its own or as a complement to existing BSC systems.

INTRODUCTION

Providers of health care services operate in a complex environment filled with paradox. Health care organizations have felt the impact of dramatic changes in the environment over the past two decades: technological advances, shifting demographics, changes in the labor market, growing disparities in income and benefits, and escalating malpractice claims and awards. In response to these external pressures, organizations have looked for new ways to think about evaluating their performance, with a particular emphasis on customer satisfaction. Unlike many service providers whose customers are often willing to accept tradeoffs between quality, timeliness, and/or price, however, when it comes to health care, most people in the U.S. today expect the highest quality services to be available immediately at affordable prices.

Kaplan and Norton's (1992) BSC approach has been widely adopted as a health care performance framework. By including internal business, innovation and learning, and customer perspectives with more traditional financial perspectives, the BSC approach is a significant improvement over previous methods of analyzing performance. However, in this paper we argue that the perspectives included in the BSC framework continue to focus too much on profit and processes and too little on people, particularly when used in health care organizations. We recommend adopting the Competing Values Framework (Quinn and Rohrbaugh, 1983; Quinn, 1988) as a way to more fully address the complexity of the health care industry. In addition to providing a more complete, theoretically grounded framework for understanding essential aspects of performance at the organizational level of analysis, the CVF has also been applied at the individual level of analysis to identify the managerial competencies needed to support the desired organizational culture.

CRITICAL ISSUES IN THE HEALTH CARE ENVIRONMENT

As with any purchase decision, consumers are concerned about the value of services received, that is, the perceived quality of the services relative to their cost. With health care services, however, consumers are often not in a position to adequately evaluate the quality of care nor can they always choose a less costly alternative when they need medical treatment. The most important service that health care organizations provide is direct medical care.

To create organizational sustainability, both the technical and functional aspects of the quality of care must be addressed. On the technical side, the elimination of medical errors and adverse effects is crucial; lives are at stake. However, the functional side of service quality, how the direct medical care is delivered to the patient, also impacts patient satisfaction and thus hospital retention and referral rates. Competence in both the technical and functional aspects requires three major components: highly trained, motivated, and empowered nurses that are adequately staffed, the appropriate technology to streamline medical processes and reduce medical error and adverse effects, and a culture where communication, both between the patient and the medical staff and between medical staff members, is encouraged and nurtured. All three components have a direct impact on medical errors. The Institute of Medicine estimates that "tens of thousands of deaths and injuries [are] caused by medical mistakes every year" (McGee 2004, 101). The FDA estimates that number to be nearly 500,000 (McGee, 2004). The FDA also estimates that half of the drug errors are preventable (McGee, 2004).

Rising costs are putting enormous pressure on providers as well as patients; however, hospitals need to look beyond the bottom line to evaluate their performance and need to recognize that cost and quality do not always require a tradeoff. As Behnke and Breyfogle (2005, p. 451) note, “If one focuses just on cost, the quality often goes down, but, if one focuses on quality, then costs generally go down!... If we could systematically apply what we currently know about quality management to health care, it has the potential to save more lives and otherwise improve health more than any other foreseeable technology or scientific breakthrough of the next 20 years, including finding new cures for diabetes, heart disease, or cancer.” Some health care organizations have attempted to improve their performance by adopting the BSC approach which considers a broader array of measure than traditional financial metrics.

THE BALANCED SCORECARD APPROACH

Kaplan and Norton (1993) developed the BSC methodology to address the problem of organizations placing too much reliance on traditional financial outcome measures that would not necessarily identify those performance metrics that contribute to the future success of the organization. The BSC measures focus on both financial and non-financial outcomes.

Balanced Scorecard Perspectives and Objectives

The BSC includes four different perspectives (financial, customer, internal process, and learning and growth) and incorporates multiple measures for each perspective. Kaplan and Norton (1996) emphasize that measures should be linked to strategic objectives, not generic data, should include both outcome and performance drivers, and should be used as the basis for short-term

and long-term strategic planning and decision-making (Gumbus, 2005; Kaplan and Norton, 1993).

The BSC approach has been widely used in health care as a strategic planning framework (Griffith, et al., 2002, Gumbus, et al., 2003, Baker and Pink, Chow, et al. (1995), Zelman, et al., (1999) and Lawrie and Cobbold, 2004). Table 1 provides examples of the focus and metrics that a health care organization might use in conjunction with each of the four BSC perspectives.

Table 1: Health Care Foci and Metrics using the Balanced Scorecard

Perspective	Health Care Focus	Health Care Metrics
Financial	maximizing revenues and managing costs	clinical, operational, and financial indicators
Customer	patient metrics, volume and market share with a goal of increased ambulatory presence and the promotion of health and wellness	patient-satisfaction survey scores, patient safety, and Joint Commission for Accreditation of Health care Organizations (JCAHO) accreditation, expanded clinical services, coordinated clinical care centers, increased ambulatory volume
Internal business process	cycle and turnaround times, enhancing efficiency	time to admit, length of stay, number of physicians connected to hospital clinical information systems
Learning & growth	Employee learning, innovation, and growth	vacancy and turnover rates, employee development plans, employee satisfaction

Problems with the Balanced Scorecard Approach

On the surface, the BSC Approach appears to provide a valid approach to strategic planning, but the approach also has its critics (e.g., Behnke and Breyfogle, 2005; Gumbus, 2005; McLean and Mahaffey, 2000). In addition to the criticisms of the approach that are discussed in the literature, we found that the human resource component of the approach is not emphasized strongly enough and the assumption that tradeoffs are required create a truly balanced approach.

The lack of emphasis on the human resource component is inconsistent with the strong human resource management focus in the Joint Commission on Accreditation of Health Care Organizations' (JCAHCO) standards, the Malcolm Baldrige Quality Award Program criteria, and the basic tenets of the total quality management philosophy. For example, the JCAHCO accreditation standards include sections for human resource management, medical staff, and nursing, and many other sections refer to human resources. All the standards of the Patient-Focused Functions, including Ethics, Rights, and Responsibilities section, the Provision of Care, Treatment, the Services, Medication Management section, and the Surveillance, Prevention, and Control of Infection section can only be achieved through the work of hospital personnel. The Leadership section overview includes a section on teaching and coaching staff; "staff education is an essential leadership function" (Joint Commission, 2005, p. LD-1), the Management of the Environment of Care section includes staff education, the Medication Management section stresses the importance of a "nonpunitive culture" (p. MM-1). The criteria for the Malcolm Baldrige Quality Award Program in Healthcare also includes core values that clearly and

explicitly emphasize valuing hospital personnel, not simply as a means toward improving customer satisfaction, but as an important end in and of itself.

Both the JCAHCO accreditation standards and the Baldrige criteria are built on a solid total quality management foundation where the employee is a critical success factor. The second principle of total quality management is participation and teamwork because "meeting the company's quality and performance goals requires a fully committed, well-trained, and involved workforce" (Evans and Lindsay, 2006, p. 25).

Despite the fact that Kaplan and Norton (2001, p. 92) included having a "motivated and prepared" workforce as an underpinning of their framework. The BSC, in the words of Kaplan and Norton (1991, p. 79), "establishes goals but assumes that people will adopt whatever behaviors and take whatever actions are necessary to arrive at those goals. The measures are designed to pull people toward the overall vision." Unfortunately, employee motivation and commitment cannot be assumed – the cliché that "what gets measured gets done" does include a grain of truth, but it is an enormous oversimplification of behavior in organizations.

Our second concern is that that the BSC appears to take as a given that tradeoffs must be made among key variables such as cost and quality (e.g., Inamdar et al., 2002). Although tradeoffs are sometimes necessary, assuming that tradeoffs are a given may impose blinders on managers who then fail to look for creative solutions that can lead to improvements in one area without sacrificing another area.

In sum, although the BSC does a good job of moving beyond simple financial performance measures, because it omits the key perspective of employees and emphasizes making tradeoffs, the BSC approach is likely to encourage an organizational culture that undervalues and overworks employees, resulting in reduced quality and increased costs in the long run. An organization's success is dependent on the ability and motivation of its employees to implement its vision. We contend that the BSC is actually unbalanced, and thus is not flexible enough to allow for the appropriate approaches to be developed, deployed, integrated, and aligned throughout the health care system to effectively and efficiently support strategic initiatives. To address this limitation, we propose using the CVF (Quinn and Rohrbaugh, 1983; Quinn, 1988) either on its own or as a complement to existing BSC systems.

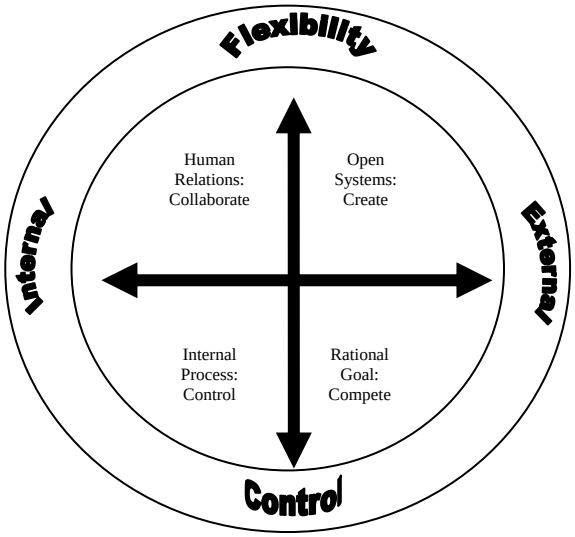
COMPETING VALUES FRAMEWORK

The CVF is a theoretically grounded approach to understanding the impact of organizational culture (Cameron and Quinn, 2005) and managerial behavior (Quinn, 1988) on organizational effectiveness. Rather than accepting tradeoffs as a necessity, the Competing Values approach emphasizes looking for ways to generate win-win outcomes by simultaneously focusing on four key action imperatives: Compete, Control, Collaborate, and Create (Quinn et al., 2007).

The CVF approach was developed by integrating multiple theoretical perspectives on management into a single framework (see Quinn, 1998 for a comprehensive discussion of these models). Early models of management tended to focus on control. Some, such as scientific

management emphasized internal process control; others, such as the rational goal model emphasized control in relation to the demands of external customers. As practitioners and researchers continued to examine the outcomes of these approaches to management, however, they identified problems. New models that focused more on flexibility emerged. The human relations school of thought began to recognize the importance of flexibility when dealing with employees inside the organization while the open systems approach began emphasizing the need for flexibility when dealing with the external environment. As shown in Figure 1, The CVF combines all four of these approaches into a single model that encourages a simultaneous emphasis on control and flexibility and internal and external factors.

Figure 1: The Competing Values Framework*



Adapted from Quinn et al. (2007, p. 12)

The CVF incorporates all of the perspectives found in the BSC approach and gives more emphasis to the importance of people relative to profits and processes, both theoretically and in practice. For example, despite the growing use of the BSC technique in the health care industry, current problems with staffing levels in health care suggest that some organizations still may be overemphasizing financial concerns, to the detriment of patient care. The current nursing shortage peaked in 2002, with 95% of nurses reporting staffing shortages during the past year; in 2004, after 185,000 nurses were been added to hospital workforces, 82% of nurses reported staffing shortages (Buerhaus, et al., 2006). Overworked hospital staffs are also unlikely to think as innovatively or learn new ways of doing things as well when they are working extensive amounts of overtime. The financial pressures faced by hospitals and other health care organizations are very real, but it is not clear that the best solution is to forego hiring sufficient numbers of nurses to provide adequate patient coverage.

The CVF recognizes that managers often face situations that appear to require tradeoffs. Organizations need to address the fundamental tension between control and flexibility and between focusing on external and internal issues. In contrast to other approaches such as the

BSC, however, the Competing Values approach does not accept the assumption that these tensions necessarily require tradeoffs. Instead, the Competing Values approach embraces paradoxical thinking and looks for ways to transcend paradox and achieve objectives that initially appeared to be in conflict. For example, because employees have a major impact on patient care, value creation, and cost containment, addressing employee concerns can also have a positive impact on key outcome such as patient satisfaction and financial performance. Conversely, decisions to cut costs by reducing staff can actually result in even higher costs. For example, Buerhaus, et al., (2005) found that over 80% of the survey respondents thought that nursing shortages affected the timeliness, effectiveness, and efficiency of care which impacts patient satisfaction levels, and over 67% thought shortages affected the safety and equity of care, which is directly related to the costs associated with medical error and adverse effects. The recommended actions of the study were primarily strategic in nature: change the workplace environment, improvement the contributions of nursing in patient quality and safety initiatives, develop at long-term focus, fix problems restricting capacity of nursing education programs, promote a balanced and professional image of nursing, improve diversity in the workplace, and recognize that changes in the workforce are possible.

CONCLUSION

Researchers in the health care industry have called for a variety of changes that reflect the need for hospitals to transcend paradox and address all four of the action imperatives identified by the CVF. For example, Abernethy and Lillis (2001) state that in order for hospitals to survive, the strategy of the organization must change to a focus on innovation, flexibility, knowledge- and enterprise-based systems, using self-managed teams and a strategically designed management system. In other words, hospitals need to operate in a more entrepreneurial manner to be more responsive to patient demands (Habib and Victor, 1991; and Slater and Olson, 2000) and to implement efficient operating systems (Abernethy and Stoelmender, 1995; Abernethy and Chua, 1996). The adoption of service innovation techniques is critical to the development of competitive strategies in rapidly changing health care markets (Carman, et al., 1996). A culture must be developed to facilitate innovation and creative thinking (Naman and Slevin, 1993), and the organizational structure must facilitate efficient flow of information, both horizontally and vertically, to develop collaborative delivery of core health care services within the organization (Bouwens and Abernethy, 2000). These types of changes cannot occur if employees are not intimately involved in identifying and implementing new ways of providing health care service.

In the health care environment, the CVF can be used in conjunction with other methods, such as the Baldrige Criteria, JACHO standards, and even the BSC to provide a comprehensive approach to meeting the expectations from multiple perspectives, including employees – the lifeblood of any health care operation. The CVF can be used to review both the culture of the organization and the competencies of individual managers. By considering managerial roles and behaviors, as well as organization goals, the CVF provides a clear link between strategy and implementation.

References Available Upon Request from Angela M. Wicks

THE LEAN TRANSFORMATION AT HENKEL LOCTITE'S R&D CENTER

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ABSTRACT

This paper describes the Lean transformation at the North American Engineering Center (NAEC) of Henkel Loctite, a large industrial adhesives company. The facility, located in Rocky Hill, Connecticut, began its Lean journey in 2001 by implementing the principles of Lean management in the design, procurement, and distribution of adhesive dispensing and curing equipment. Loctite management initially considered dispensing equipment a secondary product line needed only to augment its core product, industrial adhesives. Initial results were so successful that the company expanded its use of Lean principles into key areas of the Application Engineering Laboratory (AEL). The focus of the paper is on practical issues related to implementation, difficulties, and challenges associated with the effort.

INTRODUCTION

To address some of its operational deficiencies, a core group of experienced Henkel Loctite employees were organized into a "Lean Team." The team first concentrated on the dispensing and curing equipment operation.[1] This area contained a significant amount of service characteristics, so taking traditional Lean principles (which are primarily based on conventional manufacturing processes) and applying them in a straightforward manner was difficult. However, since the Lean Team was most familiar with the time-honored principles of Lean, it decided to adapt them for use. Their initial Lean efforts were somewhat unique because they were aimed more at service process improvement than on traditional parts manufacturing.

Initial efforts by the first Lean Team resulted in many improvements and strategic initiatives, including a downward trend in inventory costs and increased service levels. This prompted the Lean Team to expand its efforts into the Application Engineering Laboratory (AEL).

LOCTITE COMPANY BACKGROUND

Loctite Corporation began in the Trinity College basement laboratory of chemistry professor Dr. Vernon Krieble of Hartford, Connecticut, in 1953. Loctite's first product, an anaerobic thread

[1] For more information on accomplishments in the Dispensing and Curing Equipment operation, refer to the business case study; Arnheiter, E.D., and Cocco, J.J. (2003), "Loctite Corporation", *Richard Ivey School of Business*, University of Western Ontario, No. 902D19.

locking adhesive, quickly became popular as a replacement for lock washers. Loctite industrial adhesives became a popular alternative to more costly mechanical options.

In 1997, Loctite Corporation was purchased by the Henkel Group, headquartered in Düsseldorf, Germany. The company specializes in consumer brands and in industrial chemicals. With over 50,000 employees, Henkel generated sales of 10.6 billion euros in 2004.

OVERVIEW OF LEAN MANAGEMENT

Lean management can be traced to the Toyota production system (TPS), a manufacturing philosophy pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo [1]. It is well known, however, that in the late 1910's, Henry Ford's assembly plants had Lean operating characteristics, including high throughput, low inventories, and short-cycle manufacturing. In fact, Ohno greatly admired and studied Ford because of his accomplishments and the overall reduction of waste at early Ford assembly plants [2]. The TPS is also credited with being the birthplace of just-in-time (JIT) production methods, a key element of Lean production, and for this reason the TPS remains a model of excellence for advocates of Lean management.

Lean management seeks to eliminate all forms of waste, so that every activity along the value stream creates value. Efforts focused on the reduction of waste are pursued relentlessly through continuous improvement or *kaizen* events.

LEAN IN THE APPLICATION ENGINEERING LABORATORY

The AEL provided support to application engineers who were advising end-use customers. Customers were typically searching for non-mechanical approaches to bonding and fastening. Application engineers worked with customers to clarify and define the technical details under which the equipment and adhesives would operate. The support provided by the AEL started with the development of a test plan. The test plan included background, objectives, a test matrix, test procedure, and the test apparatus design. The laboratory work was then performed and the data were analyzed and reported.

The AEL Lean Team decided to focus on minimizing waste. In Lean, the categories of waste are typically classified as: (1) Overproduction; (2) Inventory in excess of immediate needs; (3) Correction necessitated by defects; (4) Motion that does not contribute to work; (5) Processing that does not add value; (6) Waiting imposed by inefficient work sequence; and (7) Handling inessential to a smooth work flow [3]. If we examine typical laboratory processes, these seven waste areas can be adapted with some modification. The potential waste areas in laboratory processes are suggested in the list below. Several of the waste categories are very generic:

- Transportation and processing inefficiencies (a smooth workflow is essential)
- Overproduction
- Defective products and mistakes
- Unnecessary reviews
- Informational duplication
- Delays

As in manufacturing, time is of the essence in the laboratory, particularly in terms of minimizing storage time, or the time that a specimen sits around waiting for something to happen (non-value-added time). One way that the Lean Team attempted to minimize wasted time was by standardizing specimen collection and processing. There are analogous situations in other laboratory settings. For instance, in a Lean blood lab, all phlebotomists would perform their work in the same way, following standardized processes, using standardized carts or trays. Also, they would work on one specimen at a time whenever possible. For example, a phlebotomist might retrieve a label, identify the patient, draw the specimen, label it, and send it by pneumatic tube to the lab [4]. In a batch environment, with multiple orders on a cart at the same time, the probability of getting someone's blood mixed up with another person's is much greater.

Standardizing the Lab Project Process

Since every set of activities can be defined as a *process* (e.g., getting married, withdrawing money from a bank, driving to work, filing an insurance claim, etc.), the Lean Team knew it should also view the work done in the AEL as a *collection of processes*. Therefore, the team first defined a standardized "Lab Project Process" in order to reduce waste and develop a starting point for future Lean efforts.

The standard process developed incorporated six primary steps, the first step being the specification of the project's test plan. In the second step, the project was entered into the NAEC online database using Lotus Notes software. The third step involved the staging of the project by the two-person team (gathering and kitting required equipment, ordering raw material, etc.). The actual laboratory work was then performed by AEL technicians. The fifth step in the process was the analysis of the test results. An increasing amount of data analysis was being performed by the AEL, so this part of the process differed from the traditional approach of having Applications Engineering (the primary customer of the AEL) analyze most of the data. By shifting more of the analysis to the laboratory, the AEL Manager was hoping to provide more of a turnkey operation for his customers. The final step in the lab project process was the creation of the engineering laboratory report.

Table I: The Standardized Lab Project Process

Step	Description
1	Develop test plan
2	Enter project into NAEC database (using Lotus Notes)
3	Project is staged (kitting, setup, etc.)
4	Laboratory work is performed
5	Data are analyzed
6	Engineering laboratory report is written

Standardized Laboratory Reports

Another application of the Lean principle of standard work can be found in Loctite's approach to its engineering laboratory reports (step 6 of the Lab Project Process). The Lean Team decided that standardizing the report produced by the AEL would benefit customers and reduce waste in the form of excess time and redundancy. The reports were designed with an eye towards the

"visual workplace" (another key Lean principle). A typical report included: a brief description of the project (e.g., "Determine if a method can be found to dispense water-based adhesive at a rate of 9 grams/second at 15 psi"), adhesives evaluated, equipment used, laboratory conditions, photos of the experimental setup, outline of the test method, a summary of the results using tables and graphs, a statistical analysis of the results, and conclusions and recommendations. An appendix contains the details of any statistical analysis required.

Setup Reduction

The Lean Team instituted significant improvements in terms of setup time. A special two-person "crib team" took care of collecting and organizing all of the required equipment and material for each job. This represented the staging step in the standardized Lab Project Process (step #3). The crib team used a classic "kitting" approach and placed the material in large, red, plastic totes (Plates 1 and 2). All jobs were placed in the same standard size tote, regardless of how much space was actually needed to hold all of the required test equipment and material. While this approach was sometimes undesirable because of wasted space in the totes, it enabled the laboratory to remain neat and organized because the totes easily stacked together. In addition to gathering materials and placing them in the red totes, each crib team was also responsible for managing the inventory system of the laboratory and performing any necessary laboratory setup for each project.

Plate 1: Project requiring full capacity of the standard tote

Plate 2: Project requiring only a small portion of tote's capacity

Lean Techniques in the Crib

The Lean Team also established a bar coding system in the crib in order to reduce customer waiting time during the kitting process, and increase accuracy of the inventory tracking and reordering procedures. The use of rolling racks minimized floor space required for inventory (Plates 3 and 4). This approach to inventory movement and storage is being used by many public and university libraries to reduce floor space needed for book stacks. Each rack contained small grey bins that were plainly bar coded and labeled, enabling the crib team to quickly locate required items. All of the Lean techniques implemented in the crib were designed to reduce the time required to locate and access the necessary tools and equipment for each project.

Plate 3: Rolling storage rack used in the crib

Plate 4: Bar coded storage bins used on the rolling storage racks

Visual Techniques

The AEL used other Lean visual techniques. For example, the status of laboratory jobs was displayed on a large plasma monitor, similar to arrival and departure information being displayed at an airport terminal. Information about each project included the project number, due date, assignee, and project manager (Plate 5). Software kept track of how many days had passed since a late project, and this information was constantly displayed at the top of the monitor.

The Lean Team never wanted information on the plasma monitor to be used for punitive purposes, but it discovered that including the assignee and project manager information had in a few cases been problematic, creating some fear and anxiety amongst the AEL staff. Rather than let this issue simmer and potentially derail improvement efforts, management held a meeting with all of the AEL staff. The staff was assured that displaying names was not a management scare tactic, but was simply a means to streamline communication (again, reducing waste) and make it easier to contact those in charge of each project.

Another visual technique commonly employed by the AEL manager and his staff was the use of post-it notes during brainstorming sessions and root cause analysis (Plate 6). Brainstorming was a commonly used continuous improvement technique, and the AEL technicians were encouraged to organize and participate in such sessions whenever problems were encountered that required corrective action.

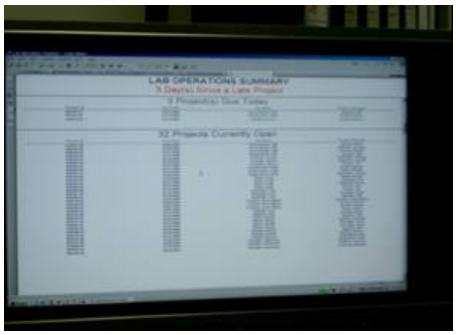

Plate 5: Large LCD monitor shows laboratory project status for each job

Plate 6: Exercise for finding the root cause for late projects

Additional Improvement Initiatives

Continuous improvement projects were very common at NAEC Engineering Services. The AEL team made improvements to the lap shear process, block shear process, and the peel testing process. The team was also looking at cross-training laboratory personnel in several key areas including advanced robotic training, machining, and fatigue testing.

FUTURE WORK AND CONCLUSION

This paper highlights the need for further work in the area of service sector applications of Lean management. The bulk of research and applications in Lean are in the manufacturing sector. There are literally hundreds of books and cases describing the use of Toyota's principles in manufacturing, but little has been written on applying Lean to the service sector. Businesses engaged in health care, insurance, banking, research, and information technology are beginning to learn about Lean. In the case of Henkel Loctite, it is apparent that the Lean Team adapted the traditional five guiding principles of Lean Management simply because a better framework was unavailable. A model for the guiding principles of service sector Lean is needed. Such a model could have great practical implications for the adoption of Lean in the service sector.

This paper represents a summary of field-based research and personnel interviews conducted at the North American Engineering Center of Henkel Loctite. The success of the first Lean Team created enthusiasm for Lean that spread to the Application Engineering Laboratory (AEL). The AEL Lean Team then creatively examined their laboratory processes and used simple but effective techniques to streamline and standardize the entire Lab Project Process. Their efforts eliminated many wasteful practices within the laboratory and enabled the AEL to take on additional responsibility and value-added work for its customers. Benefits of the Lean efforts included a deeper knowledge and understanding of customer needs, and sharply reduced lead times for laboratory projects. Also, the trust and cooperative environment created by efforts of the Lean Team led to improved worker morale and job satisfaction.

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ENHANCING THE SALES PROCESS FOR A LEADING WEALTH MANAGEMENT FIRM

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ABSTRACT

In 2006, a leading wealth management firm set a milestone to be recognized as *the* provider of choice for comprehensive, multigenerational wealth management services in America by 2010. At that time, the firm was ranked 15th. They partnered with a team from Drexel University's Executive MBA program to help them determine how best to leverage their strategic thinking to improve the sales process; and determine which promotional initiatives provided the highest ability to increase sales. Using the Strategic Service Vision (SSV) and Quality Function Deployment (QFD) methodology, the EMBA team provided a framework for optimal decision making for the firm.

Key Words: Strategic Service Vision, Quality Function Deployment, Wealth Management, Enhanced Sales and Service, Prioritizing Marketing Initiatives

INTRODUCTION

A leading wealth management firm (the Firm), founded in 1903, has consistently been at the forefront of their industry with innovative ways to meet and exceed the needs of high net worth individuals and their families. By 2006, it had grown to serve clients in all 50 states and 22 other countries. Having enjoyed a leadership role of being one of the largest personal trust providers in the United States, it was eager to establish that same top-of-mind prestige as a comprehensive wealth manager in the minds of the marketplace, offering trust, investment management and family office services. To accomplish this, the Firm set a 2010 goal to be recognized as *the* provider of choice for comprehensive, multigenerational wealth management services in the United States versus the 15th position it held.

Many initiatives were identified to ensure this goal was met. One of those initiatives included the development of a business design and value proposition to help the organization break out from beneath the "sea of sameness" within the industry. As a result of that work, a communications platform entitled, *Peace of Mind and Performance* was created. The leadership team decided to implement it throughout the marketing, sales and service areas of the organization as a means to establish a consistent way to promote the company and enhance "the client experience". It was believed that consistent messaging, grounded on the wants and needs of the high net worth individuals, would enable staff to better articulate "The Firm's Story" to current and future clients. Recognizing time was of the essence, the Firm partnered with a team from Drexel University's Executive MBA (EMBA or the Team) program to help them determine how best to leverage their strategic thinking to improve the sales process; and determine which promotional initiatives provided the highest ability to increase sales.

CURRENT ENVIRONMENT

The Firm's wealth advisory business line experienced tremendous growth and expansion between 1996 and 2006. It acquired two companies, and opened five offices in four states in less than seven years. In 1996, the sales force totaled 20 business development officers, with 15 located in Delaware and 5 located in Pennsylvania. At the end of 2006, the sales team consisted of 50 individuals located in fifteen locations throughout the United States. 25 were located in the mid-Atlantic region and the remaining 25 in offices located in New York, Georgia, Florida and California. Due to the sophisticated, entrepreneurial, and highly customized nature of the business, developing a standardized way to market and service the business was deemed unnecessary. As the company expanded outside of the greater Delaware region, however, it became very clear that standard guidelines for how they sell and service the client would be crucial to maintaining the exemplary level of expertise and service clients over multi-generations had come to expect. It was also determined that the relationship management model in place was a differentiator and needed to be leveraged to maintain their competitive advantage.

So, what should the Firm do to leverage this national sales team? They wanted to preserve the innovative and interactive nature of how the Firm's relationship managers openly and collaboratively worked with the client, experts and the client's account service team. At the same time, they also needed to standardize the use of consistent messaging and wealth planning approaches to ensure one consistent, premier client experience nationwide.

OVERVIEW OF METHODOLOGY

The EMBA team determined that the best approach to addressing these two questions was to utilize a framework developed by James Heskett during the 1980s called the Strategic Service Vision ("SSV") concept and the Quality Function Deployment ("QFD") model developed in 1972 at the Mitsubishi's Kobe shipyard ("Partovi, 2001"). The SSV concept was an ideal approach to answer the first question, because it is specifically designed to identify the key front and back room processes involved in an activity. Once processes are identified, they can be categorized based on importance and their relationship to key client wants. Before finalizing the communication platform, the EMBA team believed it was important to ensure that everyone at the Firm had a thorough understanding of not just the key processes involved in selling to prospective clients, but how each process related to specific client wants. Once these key processes and client wants were identified and agreed-upon, the Team would be in a much better position to recommend specific initiatives in the communication platform that would differentiate the Firm's approach from the rest of the field.

As for the second question, the Team believed the QFD model was ideally suited to help the Firm's management to prioritize and select four initiatives to complement the communication platform and drive increased sales. Originally, the QFD approach was developed to assist decision makers in manufacturing settings. However, it can also be applied to a service environment very effectively. The QFD model takes into consideration the interrelationships between the primary client-wants and the key processes identified though the SSV concept.

To tackle the issues, the Team created three interrelated QFD matrices. QFD 1 (Figure 1) identifies the primary client wants by market segment, and assesses how well the Firm is currently addressing those wants. QFD 2 (Figure 2) evaluates to what degree the key client wants were impacted by the key processes identified through the SSV concept. Lastly, QFD 3 (Figure 3) assesses how specific initiatives would affect the key processes, which would have the most impact on meeting clients' wants. Choosing initiatives that had the highest correlation to their clients' wants would put the Firm in the best position to meet its sales goals.

A final, but important, step in the methodology was validation, a critical component of operations management. In many cases, validation can be achieved by discussing preliminary conclusions with key stakeholders with different perspectives on the processes under review. For this project, the Team elected to present both the SSV and QFD findings to the National Sales Manager, Head of Financial Planning and Wealth Management and the Chief Operating Officer before finalizing their recommendations.

STRATEGIC SERVICE VISION

The Firm's wealth management decision-making clients are 60% male, age 65+ years and 40% females, and age 55+ with $10 million or more in investable assets. A younger group of high net worth decision makers are also valued—men and women, age 35-55. They are predominantly American with global reach; well-educated with limited interest in technology. These individuals are multi-generational families with inherited wealth, executives, entrepreneurs, business owners, and their advisors; often conservative in nature and need to feel valued; willing to take advice yet want to be listened to and respected.

In support of the business design initiative, the Firm utilized a proprietary 2005 research study entitled Millionaire Insight Research ("Market Research, 2005") to understand high net worth clients' satisfaction level with their major wealth service provider. The survey identified key characteristics or "drivers of satisfaction" for high net worth individuals with $10 million or more in investable assets. These were used to develop the company's communications platform. The EMBA team used these same characteristics for the strategic service vision analysis.

OPERATING STRATEGY

To best correlate the ability to deliver what the client wants—*Peace of Mind and Premier Performance,* the Team developed flowcharts for both front and back room sales and service processes. Through this exercise, the Team identified that the Firm had the potential to deliver "Peace of Mind" when a prospect is trying to *identify a wealth management firm* to interview through national and regional marketing activities that reinforce the stability, knowledge and expertise of the company coupled with one point of contact who values and understands them, is objective and acts in their best interests at all times. This is then reinforced in *all meetings*, conversations and events with the prospect. *All advisors* will be trained to *present the company, its capabilities and strategies* consistently. The company will also take great care in *assigning an advisor* that fits the client from an interpersonal and knowledge-based perspective to ensure the advisor can represent the client and deliver the issues/needs most effectively to the *expert team he/she assembles and leads.*

"Premier Performance" translates into a clear and articulate understanding of the issues for clients—promptness, accuracy, account management, and portfolio performance. All these things are expected to be done with the utmost integrity and productivity. The Firm has the potential to deliver this service concept when *the advisor* listens skillfully in all meetings and then *selects the expertise* needed to meet client needs. The *voice of the client will also be represented by the advisor* in *strategy development and finalization.* Experts will also be present and assist in the *presentations to clients* so expertise and knowledge can be demonstrated directly to the client and ensure nothing is lost in translation. The physical presence of the expert team also demonstrates the commitment to the need for the client to feel the Firm is providing value for money for fees paid.

QUALITY FUNCTION DEPLOYMENT ANALYSIS

The EMBA Team also identified (via the proprietary study) that the Firm had tremendous opportunity to gain new high net worth clients—today— by reinforcing performance (specifically client service and portfolio performance) to younger high net worth individuals. As it might be expected, increasing age correlates with an increased tendency to stay with their current wealth management provider. However, client loyalty to firms diminishes with age and many, especially those under 45, are open to what other providers have to offer and will consider switching to another provider.

The Quality Deployment Function tools ("Partovi, 2001") (in Figures 1, 2 and 3) were used to analyze the current book of business specific to age groups and percentage mixes opposite two of its competitors. This helped to prioritize the most important needs of the client and prioritize projects that the Team believed would help to increase sales to the target audience defined earlier in the document, with an emphasis on younger high net worth individuals with decision-making authority.

FIG. 1
QFD1: Primary Client Wants by Age; Goals to Increase Sales by 2010

		PRIMARY CLIENT WANTS													
SEGMENT	Market Mix%	Stable Company	Trusted Advisor	Expert Knowledge	Premiere Client Service	Above Market Returns	High Ethical Standards	Good Value	Current Situation	U.S. Trust	Merrill Lynch	Company Goal	Improvement Ratio	Weighting Factor	Normalized Score %
< Age 35	5.0	1	1	9	1	9	1	9	500	6%	18%	***1,000***	2.00	10.0	***7.1***
Age 35 to 55	25.0	3	9	3	3	3	3	9	2,500	30%	26%	***5,500***	2.20	55.0	***39.3***
> Age 55	70.0	9	9	3	9	3	9	3	7,000	54%	56%	***7,500***	1.07	75.0	***53.6***
Total	3,321.4	607.1	842.9	342.8	607.1	342.8	607.1	578.6	10,000	90%	100%	***14,000***		140.0	***100.0***
Weighting %	100.0	***18.3%***	***25.4%***	***10.3%***	***18.3%***	***10.3%***	***18.3%***	***17.4%***							

FIG. 2
QFD 2: Key Processes Ranked by Client Want

PRIMARY CLIENT WANTS	Importance Weights	KEY PROCESSES: Learn about Firm/Capabilities	Determine Expertise	Lead the Team	Develop Wealth Mgmt Strategy	Finalize Wealth Mgmt Strategy	Present Wealth Mgmt Strategy	Outline Account Servicing	Discuss & Clarify Issues/Ideas
Stable Company	*18.3*	9					1		
Trusted Advisor	*25.4*	1	9	3	9	3	9		3
Expert Knowledge	*10.3*	9	3	9	3	9	3		
Premiere Client Service	*18.3*	9	3				3	9	3
Above Market Returns	*10.3*	1		3		9			
High Ethical Standards	*18.3*	3	3	9		3	3	3	1
Good Value	*17.4*	3		3	3	3	1		
Total	2,655.3	564.7	369.1	416.8	311.6	369.0	404.8	219.4	149.3
Weighting %	100.0%	***21.3%***	***13.9%***	***15.7%***	***11.7%***	***13.9%***	***15.2%***	***8.3%***	***5.6%***

FIG. 3:
QFD 3: Key Service Delivery Initiatives Prioritized for 2007 Implementation

KEY PROCESSES	Importance Weights	SERVICE DELIVERY INITIATIVES: Advisor Training (WT Story)	Client Contact System	Portfolio Reporting System	National Advertising Campaign	Nationwide Client Survey	Financial Planning Process	Regional Event Marketing	Client Service Training
Learn about Firm/Capabilities	*21.3*	9		3	9	3	9	3	1
Determine Expertise	*13.9*	9				3	3	1	3
Lead the Team	*15.7*	3				3	3		
Develop Wealth Mgmt Strategy	*11.7*	3				3	9		3
Finalize Wealth Mgmt Strategy	*13.9*					3	9		1
Present Wealth Mgmt Strategy	*15.2*	9				3	1		
Outline Account Servicing	*8.3*			9		3		3	9
Discuss & Clarify Issues/Ideas	*5.6*	3				3	3	3	9
Total	2,098.8	552.9	-	138.2	191.4	316.9	543.1	119.4	237.0
Weighting %	100.0%	***26.3%***	***0.0%***	***6.6%***	***9.1%***	***15.1%***	***25.9%***	***5.7%***	***11.3%***
Final Ranking		***1***	***8***	***7***	***5***	***3***	***2***	***6***	***4***

RECOMMENDATIONS

As previously discussed, QFD analysis is designed to tie product offerings and service delivery systems directly to client wants and needs. QFD 1 shows that high net worth individuals primarily look for the following qualities in choosing among wealth management firms: a stable company, a trusted advisor, premier client service and high ethical standards. Based on QFD 2, it was determined that these wants are most directly impacted by the following key processes in the sales cycle: learning about firm capabilities, leading the team, and presenting wealth management strategies. Therefore, initiatives

designed to improve these key processes will have the largest impact on future sales. In QFD 3, eight different initiatives were analyzed in order to select the four most closely aligned with client wants. Based on this analysis, the Team recommended the Firm move forward with the following initiatives: Advisor Training, The Financial Planning Process, a National Client Survey and Client Service Training.

VALIDATION PROCESS

Of the recommendations made to the Firms senior leadership, they were most impressed with the focus on enhancing the Financial Planning process to improve the important activity of "Developing the Wealth Management Strategy". After considerable dialog, it was determined that the process could be further enhanced by making additional investments in the number of financial planners available in each of the Firm's regional markets. By upgrading the financial planning tools and adding staff, financial planners could be available to accompany the relationship manager on qualified sales calls, service calls and firm-to-firm meetings. This would be particularly helpful to relationship managers who are not well versed in all areas of wealth management expertise and expedite the ability to develop the appropriate financial or estate planning strategy to meet the client need. They were also very supportive of the Advisor Training recommendation as a means to improve the "Developing the Wealth Management Strategy" activity. In addition to training the advisor on "The Firm's Story", the idea was generated to train relationship managers on *"How to listen for issues that trigger the wealth management planning process"*. This training directly supports the financial planning process and further improves our ability to create, develop and deliver comprehensive financial strategies.

CONCLUSION

The SSV process helped to identify eight important activities within the Firm's wealth advisory sales process to fully leverage the communications platform *Peace of Mind and Premier Performance*. The recommendation to develop primary messaging to substantiate how each of these key processes is unique to the Firm was approved for implementation in 2007. The recommendation to put these differentiating processes into action via staff training, and highlighting the Firm "back office" processes in marketing and sales materials (without giving away the operational strategy) was also approved. The QFD process was an effective means of assessing key client wants and service delivery processes. It enabled senior leadership to select four specific initiatives that would have the most direct impact on the sales process. The final step, a validation meeting with key company representatives, was also extremely helpful. This valuable input allowed the EMBA team to modify one of their recommendations and gain assurance that all of our recommendations were consistent with the long-term goals of the Firm.

References are available upon request from Fariborz Partovi or Cynthia Conway.

MAXIMIZING CUSTOMER LIFETIME VALUE FROM AN OPERATIONS PERSPECTIVE

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ABSTRACT

Customer lifetime value has been an extensively researched concept in marketing for many years. However, we treat CLV from an operations management perspective and redefine it in terms of customer retention rate and customer retention cost. We adopt a nonlinear programming approach to determine optimum customer retention costs that result in maximization of the CLV. A numerical example is presented to illustrate the concept.

INTRODUCTION

Customer lifetime value is a marketing metric that projects the value of a customer over the entire history of that customer's relationship with a company. Use of CLV as a metric tends to place greater emphasis on quality of customer service and long-term customer satisfaction. Long term satisfaction requires high retention rate and customer retention is the responsibility of operations function. To achieve a high retention rate, the quality of service provided must be high. Maintaining a high quality of service may translate to spending high amount on the customer to provide quality service. In some service organizations the life span of customer is limited. In such situations, service organizations may try to obtain optimum spending per customer during the limited time span to maximize average CLV.

The motivation to obtain an expression for optimal retention spending per customer arose because of considerable disagreement according to Huff et al. (1996) concerning the relationship between customer satisfaction and productivity. Reichheld and Sasser (1990) argue that reducing the number of defects leads to greater loyalty. Extending the aforementioned argument in our "service" context, it would translate to arguing that by providing better quality service to customers, customer loyalty increases and that in turn, leads to higher retention rate. A higher retention rate is desired since it means a higher CLV. However, the pursuit for maximizing CLV by maximizing retention rates by providing customers with improved quality of service may not necessarily lead to maximizing the CLV. It is because substantial amount may be spent in improving the quality of service provided. This substantial amount known as retention cost

though on one hand will increase the retention rate but on the other hand, lower the net profit gained from the customer over a period of time.

We model CLV as a function of retention rate and retention cost. However, there exists a relationship between retention rate and retention cost that will be explained in later section. Owing to the relationship that exists between retention rate and retention cost, the maximization of the CLV will lead to a solution that determines the optimal retention spending per customer.

Figure 1 illustrates the relationship between retention cost and CLV. In this figure, the amount for the gross contribution and retention cost component is projected over the four year time span discounted at the current year. The net profit is also projected over the time span discounted at the current year. The sum of the net profit over the time span will yield current CLV.

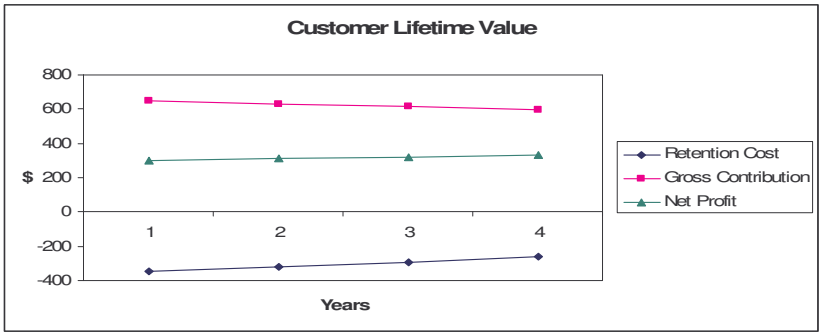

Figure 1: Customer lifetime value

In the next section, we present the literature survey and in the following section, we present the estimation of CLV. In the following section, we describe the cost to retain customers followed by a section on the maximization of CLV. In the following section, we present a numerical example and its results followed by conclusion.

LITERATURE SURVEY

Kotler and Armstrong (1995) define a profitable customer as a person, household, or company whose revenues over time exceeds, by an acceptable amount, the company costs that consist of attracting, selling, and servicing that customer. In other words, the authors define CLV as the net profit that the company can expect from a customer over a period of time. Richard and Teal (1996) state that the increase in profits by having a long time customer may be attributed to the added profits from sales through referrals, profit from cost savings obtained by serving an old customer and revenue growth from a long time customer due to increase in sales to that customer. The profits may also be attributed to the price premium paid by loyal customers. These attributes are commonly held reasons for increase in profitability from long term customers. V. Kumar, Girish Ramani, and Timothy Bohling (2004) outline some of the best practices in the area of customer value management that firms can adopt for their businesses. As quoted by Kumar et al. (2004), the challenge for a firm today is to 'implement an optimal blend of differential levels of treatments so that over every customer's lifetime, the profits earned by the

firms are maximized'. Sid Chadwick (2005) states that "Your customers can do much more for you than just pay their bills". He states that customers can bring new ideas and opportunities, not to mention new clients. He also states that to improve revenues and performance margins, current customers should not be overlooked. D. Collings and N. Baxter (2005) refer to a customer as a revenue-producing asset. Financial engineering tools, such as portfolio and options theory, then become natural means to analyze the customer's value further. In particular, the uncertainty in the future profits created by a customer can be shown to create an added dimension to the value a customer brings to the business. Marilyn Carp (2005) asks to embrace lifetime customer value. She says that acquiring customers is expensive. So retention is important. By learning more about current customers, a service firm can effectively identify new needs as they occur during the customer's lifetimes. This along with sophisticated modeling and targeting techniques, enable the service firm to offer the right product at the right time to the right person using the right media. Berger and Nasr (1998) were the first to examine a series of models for the calculation of CLV. Blattberg and Deighton (1996) use CLV as the basis for determining independently, the optimum amount of acquisition spending and retention spending. Berger and Nasr-Bechwati (2001) extend that work to a constrained allocation of promotional spending between acquisition and retention. According to Venetis and Ghauri (2004), quality of services is considered to be a critical success factor for contemporary service companies. They state that contribution of service quality to profitability is generally explained by two underlying processes. First, service quality is regarded as one of the few means for service differentiation and competitive advantage which attracts new customers and contributes to the market share. Second, service quality is viewed as an important means for customer retention.

From the above literature survey, we observe that CLV is an important metric which when maximized, yields maximum profits. In our model for calculation of CLV, we replace the marketing cost in one of the popular expressions for CLV by Berger and Nasr (1998) with retention cost that implicitly includes cost of service, cost of infrastructure, etc.

CUSTOMER LIFETIME VALUE ESTIMATION

Currently, there are various mathematical models available in marketing literature to determine the CLV. One of the popular models proposed by Blattberg and Deighton (1996) is a simple model for helping managers determine the optimal balance between acquisition and retention spending. This model is the result of a decision-calculus approach that breaks down a complex problem into smaller, simpler elements and asks the manager to form judgments about each element separately. The approach then uses a formal model (an equation) to combine the judgments into the answer to a more complex question. For further details, the reader is also advised to refer to a paper titled "The optimal ratio of acquisition and retention costs" by Phillip E. Pfeifer.

We define a modified CLV model from an operations perspective with no acquisition cost component in it is as follows:

$$CLV = \sum_{i=1}^{n} [GC_i - R_i] \times r^i / (1+d)^i] \quad (1)$$

where GC_i is the expected yearly gross contribution margin per customer, d is the discount rate per year, r is the yearly retention rate, n is the length in years of the period over which cash flows are to be projected, i is the year index, and R_i is the retention spending per customer per year. We assume that yearly spending to retain customers does not necessarily decrease with time while the gross contribution margin per customer increases with time.

RELATIONSHIP BETWEEN RETENTION RATE AND RETENTION COST

The Blattberg and Deighton model assumes that r, the retention rate per customer, is a decelerating function of R, the dollar retention spending per customer per period. The relationship between retention rate and retention cost is as follows:

$$r = r_0(1 - e^{-kR}) \tag{2}$$

where parameter r_o is known as the retention ceiling rate, which is the maximum rate of retention a firm can achieve with limitless spending on retention per customer. Parameter k can be determined once the current retention spending and the retention rate are known. For different service firms, the retention ceiling rates and the parameter k vary. The implication of this relationship between the retention rate and the retention cost is important to us from the standpoint of maximizing the CLV. In the expression for the calculation of CLV, we substitute the expression for variable r in terms of variable R. There exists an optimal value of variable R which maximizes the CLV.

Cost to retain customers

On similar lines to the assumption made by Blattberg and Deighton, cited in the previous section, we suggest that retention cost per customer is an accelerating function of time given by the following relationship:

$$R_i = R_o(2 - e^{C(i-1)^2}) \tag{3}$$

where R_i is the retention spending per customer for a given year i, R_o is the amount set for retention spending per customer in the first year, C is a parameter which determines how fast the retention cost per customer is decreased with passage of time. We can set C as a variable in the objective function so that when we optimize, we find an optimal value of C that will maximize the CLV. In other words, the optimal value of C will determine the rate of reduction on retention spending per customer.

Determination of Gross Contribution of each customer over a time horizon

It has been a common knowledge that a loyal customer spends more money over time. We assume that GC increases every year at a fixed addition rate a. Hence, in a given year i, the expression for gross contribution would be as shown below:

$$GC_i = GC_o(1 + a)^{i-1} \tag{4}$$

where GC_i is the gross contribution in the given year per customer, a is the addition rate per year, and GC_0 is the gross contribution from the customer in the first year.

MAXIMIZING THE CUSTOMER LIFETIME VALUE

In this section, we determine the optimal cost of retaining a customer that will maximize CLV. We formulate the problem as follows: Maximize

$$CLV = \sum_{i=1}^{n} [GC_o(1+a)^{i-1} - R_o(2 - e^{C(i-1)^2})] \times r_i^{\,i} / (1+d)^i \quad (5)$$

Subject to:

$$r_i \geq 0 \quad (6)$$

$$r_i \leq 1 \quad (7)$$

$$R_o \geq 0 \quad (8)$$

Now r_i is a function of R_i as shown earlier. By replacing r_i in terms of R_i in the expression for CLV, we obtain CLV with the unknown variables being the variable R_i and the variable C. The expression for CLV in terms of R_i and C is as shown below:

$$CLV = \sum_{i=1}^{n} [GC_o(1+a)^{i-1} - R_o(2 - e^{C(i-1)^2})] \times [r_0(1 - e^{-kR_i})]^i / (1+d)^i \quad (9)$$

We observe that keeping retention cost very low may not be the best solution to maximize CLV since the retention rate will reduce and will tend to lower the CLV. On the other hand, keeping retention costs very high in order to obtain a high retention rate may also not lead to a high CLV since the difference between gross contribution and retention cost would be too low which in turn will lower the CLV. There is an optimum value of R_o, on which R_i is dependent, that maximizes the CLV. The reformulated non linear programming problem that has R_i in terms of R_o is as follows: Maximize

$$CLV = \sum_{i=1}^{n} [GC_o(1+a)^{i-1} - R_o(2 - e^{C(i-1)^2})] \times [r_0(1 - e^{-kR_o(2-e^{C(i-1)^2})})]^i / (1+d)^i \quad (10)$$

Subject to:

$$R_o \geq 0 \quad (11)$$

$$\sum_{i=1}^{n} R_o(2 - e^{C(i-1)^2}) \leq \sum_{i=1}^{n} [GC_o(1+a)^{i-1} \quad (12)$$

NUMERICAL EXAMPLE AND ITS RESULTS

Let us assume that a firm is expecting an initial gross contribution margin per customer of $500. Let the discount factor be 8%. Let the number of years (n) that the firm wishes to calculate the CLV be 5 years. Let the addition rate be 5%. Now we proceed to obtain the relation for r in terms of R. Let us assume that the maximum possible retention rate for a firm is 65%. Also assume that firm has recorded that by spending $200 per customer per year, the firm secured a retention rate of 40%. k can be determined from logarithmic transformation of equation 2 and substitution of parameter values into the transformed equation.

Further, let r = 40%. Since r_0 = 65% and R = $200, value of k is determined to be 0.0048. The assumption here is that the value of k calculated for different observations of retention spending and retention rates will consistently be the same value with little or no variation. The reader is

advised to refer to the original derivation of Blattberg and Deighton CLV model for more information on the aforementioned assumption.

Our non linear optimization problem is as follows: Maximize

$$CLV = \sum_{i=1}^{5} [500 \times (1+0.05)^{i-1} - R_o(2 - e^{C(i-1)^2})] \times [0.65 \times (1 - e^{-0.0048 \times R_o(2-e^{C(i-1)^2})})]^i / (1+0.08)^i \quad (13)$$

Subject to

$$R_o \geq 0 \quad (14)$$

$$\sum_{i=1}^{5} R_o(2 - e^{C(i-1)^2}) \leq 2762.82 \quad (15)$$

Running the nonlinear programming problem using SNOPT solver from NEOS server, the optimal value of initial retention expenditure is found out to be about $188.13 per customer. The optimal value of *C* is found to be -0.3649. The maximum CLV obtained is $203.96 per customer. The results indicate that the firm should invest $188.13 per customer for the first year. The retention rate that the firm can expect at the end of year 1 is:

$$r_1 = 0.65 \times (1 - e^{-0.0048 \times 188.13}) = 0.3854 \quad (16)$$

For the subsequent years, the firm must invest the amount illustrated in table 1 on retention of customers. The firm could expect the following retention rates over the subsequent years shown in the same table below.

Year	Retention Cost per customer ($)	Retention rate
2	245.64	0.4489
3	332.54	0.5173
4	369.20	0.5386
5	375.70	0.5420

Table 1: Optimal retention cost per customer

CONCLUSION

This is a preliminary work done in defining customer lifetime value from an operations perspective. We have simplified the metric to demonstrate the application of CLV to a service organization and numerically determined the optimum CLV. It is the quality of service of operations of any industry that encourages the customer to return over a period of time and contribute to the industry's profit. We have not explicitly addressed the contribution to the CLV due to referrals since it is well established that higher retention rates imply higher referrals and hence more profit. The proposed model can be modified to include the retention rate as a constraint. More specific models better suited for specialized operations can be modeled along similar lines. The retention costs can be further divided into various cost components such as cost of infrastructure, employee training, etc and incorporated into the model.

References available upon request from Khalid Habib Mokhashi.

ARE FOREIGN INVESTORS HAVE BETTER INVESTOR SENTIMENT TIMING ABILITIES? EVIDENCE FROM TAIWANESE MARKET

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ABSTRACT

This study examines whether and how futures market sentiment and stock market returns heterogeneously influence trading activities of foreign institutional investors and domestic individual investors in Taiwanese equity markets. The empirical results suggest that both foreign institutional investors and domestic individual investors are net sellers whenever futures market sentiment is bullish and are net buyers when the futures market sentiment is bearing. Furthermore, this investigation observed that foreign institutional investors are informed positive feedback traders, while domestic individual investors are contrarian in their buying decision and momentum traders in their selling decisions. In summary, this study concludes that foreign institutional investors have better ability to time market sentiment than local individual investors.

Keywords*:* Investor sentiment; quantile regression; momentum

1. INTRODUCTION

Recent decades have seen emerging economies open their doors to foreign institutional investors and establish futures exchanges to accelerate the liberalization and internationalization of their financial markets. Futures markets provide advantages to economic agents in the form of risk management and price discovery. Additionally, there is a dynamic interplay between the spot and futures markets, and sentiment in the latter can be transmitted to the former. Financial economists are always interested in the trading behaviors of foreign institutional investors (hereafter foreigners) and domestic individual investors (hereafter individuals). We first examine whether futures market sentiment influences the spot market trading behaviors of foreigners and individuals. Two alternative perspectives on trading strategies have been established to explain how the trading behaviors of investors relate to past returns: momentum and contrarian strategies. These models demonstrate that investor trading activities vary with past stock returns. Second, we explore whether foreigners and individuals are engaged in feedback trading.

It is generally accepted that institutional investors are less likely than individuals to violate axioms of rationality owing to following strict trading guidelines and operating under supervision, but recent evidence has contradicted this view. There is growing debate regarding possible links between investor behavior and market sentiment (De Long, Shleifer, Summers and Waldmann (1990); Baker and Wurgler 2006). A theoretical framework describing influence of investor sentiment on stock price was proposed by De Long et al. (1990), and Barberis, Shleifer and Vishny (1998). According to this theory, investors believe that trading activities in the futures market provide an alternative means for predicting future price movements. With stocks

underpriced when investor sentiment is low and overpriced when sentiment is high, it is interesting to examine whether foreigners and individuals in the spot market can time investor sentiment in the futures market.

Taiwan allowed equity investments by foreigners starting from 1991, and the Taiwan Stock Exchange Capitalization Weighted Index Options (TAIEX Options) listed on December 24, 2001. The main advantages that futures markets offer are price discovery and risk management via hedging. Taiwan has not surveyed investor sentiment. The put-call ratio of TAIEX options in the futures market can be considered a proxy of investor sentiment among spot market participants.

In summary, we investigate whether futures market sentiment and stock market returns heterogeneously influenced the trading activity of foreigners and individuals in the spot market. This study makes the following three contributions to literature: (1) assessing behavioral differences between foreign institutional and local individual investors trading in Taiwan's stock market; (2) rating the impact of futures market sentiment on investor trading activity in the spot market; and (3) providing a more detailed picture of covariate effects by estimating a family of conditional quantile functions, and comparing them with the OLS estimates. The remainder of this paper is organized as follows. Section 2 describes data. Section 3 presents our empirical approach. Section 4 then discusses findings, and finally Section 5 presents concluding remarks.

2. DATA DESCRIPTION AND STATISTICS

We employ the unique data for buying (margin trade) and selling (redemption of margin trade) dollar values of margin traders as foreigners (individuals) trading activities. The available daily data has covered the period from January 2, 2002 to June 30, 2006, containing 996 observations. Daily data enables us to evaluate the immediate impact of previous day sentiment on the trading activities of different categories of investors. We use buy-sell imbalance as a proxy for investor trading behavior. The put-call ratio measures market participant sentiment derived from options, which is equal to trading volume of put options divided by that of call options. Put-call ratio provides an excellent window on investor sentiment. When investors are bearish and speculation in puts becomes excessive, the put-call ratio will be high, and vice versa. This put-call ratio is a contrarian indicator of market sentiment.

The average daily buy-sell imbalances are 6.036 and 0.102 for foreigners and individuals, respectively. Foreigners trade more actively than individuals, and are clearly the largest net buyers. The mean value of the futures market put-call ratio is 0.920, showing that investors in the Taiwan futures market are slightly bullish. TAIEX options were listed on December 24, 2001. We compare trading behavior of foreigners and individuals during the pre- and post-listing periods. Our empirical results reveal that foreigners behave differently between the two periods, whereas individuals do not. Evidence suggests that trading activities of individuals significantly differ from those of foreigners during both time frames. After the listing of the TAIEX options, foreigners increased their total investment in the Taiwan stock market, possibly due to the price discovery function provided by the futures market. Motivated by Kamesaka, Nofsinger and Kawakita (2003) we assess the cumulative performance of foreigners and individuals over the sample period. Empirical result shows foreigners earning about 9 billion and the individuals clearly ending up as the losers, losing approximately 1.2 billion New Taiwan dollars over the

sample period.

3. EMPIRICAL APPROACH

In empirical studies, a standard approach involves specifying a liner regression model and estimating its unknown parameters using the ordinary least squares (OLS) or least absolute deviation (LAD) methods. Mean and median are two key location measures representing "average" behavior or "central" tendencies of a distribution, but provide little information on distribution tail behavior. For the conditional distribution, characterizing only conditional mean and/or median behavior is inadequate (Kuan 2004). Koenker and Bassett (1978) proposed a quantile regression approach that estimates various quantile functions of a conditional distribution. Quantile regressions provide snapshots of different points on a conditional trading imbalance distribution of investors, and represent a parsimonious method of describing overall investor trading imbalance distribution and should be more valuable if the relationship between the investor trading behavior and market sentiment evolves across its conditional distribution.

4. EMPIRICAL RESULTS

Quantile analysis was performed to calculate bootstrapped standard errors, and repeated 1000 times in this study, for quantile regression estimators. To compare the coefficients of the two tail quantiles, this study conducted inter-quantile regression to examine the heterogeneous impacts of the explanatory variables on the dependent variable.

4.1. Investor Sentiment

Table 1 shows that OLS estimation indicates a positive correlation between foreigners trading activity and previous futures market sentiment. From the quantile regression results, the coefficients for sentiment index, from quantiles 0.1 to 0.8, are significantly positive. From the lower quantiles, the futures market sentiment positively impacts foreigner behavior, indicating that foreigners are net sellers rather than net buyers following bullish periods. For the upper quantiles, expect for the 0.9 quantile, coefficients are also significantly positive, indicating that when the futures market is bearing, foreigners are net buyers of securities. We believe this phenomenon may result from foreigners having the ability to time market sentiment, thus moving more money into the spot market when investor sentiment is low and withdrawing money when investor sentiment is high, enabling them to exploit profits when investor sentiment is reversed in the future. Besides the above variations in magnitude across quantiles, from inter quantiles, significant differences exist in market sentiment effects—0.8/0.2, 0.7/0.3 and 0.6/0.4 quantiles. Sentiment exerts heterogeneous effects on foreigners trading activity at these quantiles. The empirical results for individuals are analogous to foreigners'.

Our empirical results indicate that both foreigners and individuals have market sentiment timing abilities, being net buyer when stocks prices are undervalued due to low investor sentiment and being net sellers when stock prices are overvalued owing to high investor sentiment. Previous section shows that foreigners earn higher cumulative returns than individuals. De Long et al. (1990) argue that the optimal strategy for sophisticated investors is a market timing strategy involving increasing exposure to stocks following price declines and decreasing exposure to stock following price rises. Such a strategy of betting against noise traders is a contrarian

investment strategy, and requires investment in the market at times when noise traders are bearish, in anticipation that their sentiment will recover.

Table 1: Quantile, inter-quantile and OLS regressions

An empirical model is specified as follows:

$BSI_{i,t} = \beta_0 + \beta_1 Sent_{t-1} + \beta_2 Risk_{t-1} + \beta_3 \mathrm{Re}turn_{t-1} + \beta_4 Turnover_{t-1} + \beta_5 Value_{t-1}$ ◦ Put-call ratio is adopted as a proxy for market sentiment, and daily highest-lowest market index difference is taken as a proxy for market risk.

	quantile									Inter-quantile				OLS
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.9/0.1	0.8/0.2	0.7/0.3	0.6/0.4	
Foreign investors														
sent	13.654	22.640	19.674	18.169	15.550	13.089	10.051	11.272	4.951	-8.702	-11.368	-9.623	-5.080	14.302
p-val.	0.027	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.186	0.197	0.039	0.027	0.043	0.000
Risk	-0.105	-0.074	-0.053	-0.036	-0.033	-0.030	-0.048	-0.032	-0.048	0.057	0.042	0.005	0.006	-0.057
p-val.	0.016	0.030	0.104	0.065	0.108	0.097	0.022	0.114	0.042	0.231	0.229	0.879	0.741	0.001
Return	3.998	4.471	5.346	5.515	5.269	6.307	6.462	5.402	4.236	0.238	0.931	1.116	0.792	4.681
p-val.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.833	0.257	0.111	0.131	0.000
R^2	0.083	0.101	0.111	0.121	0.121	0.121	0.108	0.092	0.067	0.083	0.101	0.111	0.121	0.167
individual investors														
sent	5.545	5.878	3.954	4.024	3.797	3.075	2.943	2.334	2.056	-3.490	-3.543	-1.011	-0.949	4.434
p-val.	0.003	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.019	0.077	0.014	0.349	0.167	0.000
Risk	-0.029	-0.007	-0.009	-0.010	-0.005	-0.007	-0.005	0.000	0.004	0.033	0.007	0.004	0.003	-0.010
p-val.	0.068	0.483	0.151	0.068	0.298	0.115	0.295	0.953	0.580	0.045	0.492	0.582	0.486	0.039
Return	0.706	0.642	0.345	0.285	0.280	0.109	-0.097	-0.330	-0.546	-1.252	-0.972	-0.442	-0.176	0.183
p-val.	0.001	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.000	0.019	0.140	0.189
R^2	0.089	0.089	0.086	0.093	0.087	0.080	0.065	0.049	0.048	0.089	0.089	0.086	0.093	0.128

Trading imbalances of foreign and individual investors may reflect investor sentiment in the spot market. We focus on sentiment transmission across the futures and spot markets for foreigners and individuals, using the three-variable Vector Autoregression Model (VAR) model. To save space, we not report table. The variance decomposition of VAR shows that foreigner sentiment is typically explained by futures market sentiment, reverse is true. Individual sentiment in the spot market is motivated by foreigner sentiment in the short term, indicating intra-market sentiment transmission; futures market sentiment influences individual sentiment in the long term, indicating inter-market sentiment spillover.

4.2. Feedback Trading

According to empirical results estimated by quantile regression, statistically significant relationships exist between previous market returns and foreigners trading activities for all quantiles. Meanwhile, the OLS method overestimates the effect of market returns on foreigner activities for the two tails of the conditional net-buy-sell distribution. Table 1 demonstrates a positive and significant correlation between market return and individual trading behavior for the

lower quantiles. Individuals selling activities appear to be caused by past negative market return: namely, net selling occurs when market returns are negative. For the upper quantiles, a negative relationship is found between individuals buying activities and market returns, implying individuals buy more securities when past market returns are negative. In sum, individuals are contrarian in their buying decision and momentum traders in their selling decisions.

Market return does not influence individual trading behavior when assessed with the OLS method, as shown in Table 1 (p-value is 0.189). Notably, the asymmetric effects between market return and individual trading activity are traded off for the lower and upper quantiles. Hence no significant relationship is found for OLS estimates. Quantile estimates are clearly encouraging, and empirical results indicate a strong positive/negative correlation between market return and individual trading behavior for the tail quantiles. The empirical findings facilitate understanding of the structural effects of market return on individual trading behavior in the spot market. However, OLS reveals no such effect across the individual buy-sell imbalance quantiles.

Debate continues regarding whether investor trading behaviors are affected more by information regarding fundamental value or by psychological biases. Therefore, both information- and behavior-based theories predict that investors may engage in positive feedback trading. The information-based models assume trading is based on informational signals and suggest that informed investor trading behavior would exhibit momentum. Such momentum trading can move prices toward equilibrium. Behavior-based models indicate that investor decisions are influenced by cognitive errors like overconfidence. Such behaviors can cause temporary price bubbles. The subtlety of models lies in performance following the trading day. Positive feedback trading with high return hints at trading driven by information, while trading with low return suggests trading motivated by psychological factors (Kamesaka et al. 2003).

Table 2: Market performance following trading

Foreigners and individuals are defined as buy-sell imbalance for foreign and individual investors, respectively. *Denotes significance at the 1% level.

	One-week		One-month		Two-month	
Variable	Coe.	Prob.	Coe.	Prob.	Coe.	Prob.
Constant	-0.094	0.333	0.205	0.291	0.698*	0.006
Foreigners	0.039*	0.000	0.053*	0.000	0.079*	0.000
individuals	0.018	0.248	-0.087*	0.005	-0.119*	0.003
Adjusted R-squared	0.071		0.038		0.049	

The previous evidence demonstrated the association of foreigners trading with momentum and foreigners have sentiment timing abilities, and thus that their trading achieves high returns. To examine robustly the above conclusion, we regress 1-week, 1-month and 2-month intervals cumulative return following the trading day on the buy-sell imbalances of the foreigners and local individuals. Table 2 shows all coefficients of net trading activities for foreigners are positive for one-week, one-month, and two-month intervals following the trading day. However, for individuals, the coefficients of one-month and two-month intervals cumulated returns following the trading day are significantly negative. The regression empirical results suggest that foreigners achieve positive returns following their buying decisions, and negative returns after their selling decision. Individuals appear to have contrary results, individuals suffer losses after

net buying, and stock they have been invested in rise following net selling. Previous section reveals that foreigners outperform individuals; here we prove that trading activities of foreigners efficiently forecast future return. We identify positive feedback trading of foreigners is consistent with information-based model.

Intriguingly, our empirical results suggest that both foreigners and individuals have the ability to time market sentiment; however, foreigners achieve higher return than individuals. Notably, these distinct empirical differences may be due to continuation of stock prices, which results in foreigners gaining from their informed momentum strategies. Second, it is possible that individuals, who collectively tend to mistime the sentiment cycle, are among the first sellers during upswings in sentiment and among the first buyers during downswings in sentiment. In line with the empirical findings reported on Table 2 for individuals the coefficients of one-month and two-month interval following the individual trading day are significantly negative.

5. CONCLUDING REMARKS

In this study, we aim to examine the heterogeneous effects of market return and futures market sentiment on foreigners and individuals trading behavior using quantile regression. Foreigners are identified as the long term winners. The quantile regression results reveal that foreigners and local individuals are net sellers when market sentiment is high, and net buyers when the market sentiment is low. This finding implies that both groups have market sentiment timing abilities. Finally, this study demonstrated that foreigners are informed momentum traders. However, we document that individuals are contrarian investors in their buying decision and momentum traders in their selling decision. In sum, we found that foreigners outperforming local individuals may due to better sentiment timing and information-induced momentum trading strategy. Our empirical results provide a clue regarding why foreigners outperform locals in emerging markets.

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MANAGING EXPLORATION AND EXPLOITATION: THE CASES IN TAIWAN

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ABSTRACT

The exploration and exploitation approach in konwledge management has been a focus of interest in the fields of technology management, technology transfer, organizational learning and organizational adaptation. Exploration implies firm behaviors Exploration and exploitation have become as two popular concepts underpinning knowledge management since March's publication(1991). It is still debatiing whether exploration and exploitation are trade-off or ambidextrous for organizational adaptation. A comprehansive literature review is summarized and a case in Taiwan is showned in this article to indicate the balance of exporation and exploitation.

INTRODUCTION

The exploration and exploitation approach in konwledge management has been a focus of interest in the fields of technology management, technology transfer, organizational learning and organizational adaptation. Exploration implies firm behaviors characterized by search, discovery, experimentation, risk taking and innovation, while exploitation implies firm behaviors characterized by refinement, implementation, efficiency, production and selection(March, 1991). When a new technology emerges and reveals uncertain opportunity, a firm may choose to exploit the existing technology for short term survival or to explore the new technology for long term competitive advantage. A strategic choice arises between the balance of exploration of new opportunities and exploitation of existing opportunities, which has been a fundalmental issue for organizational adaptation. The theoretical literature concludes two contrasting arguments to deal with this dilemma: a trade-off or an ambidexterity. Are they two ends of a continuum or orthogonal to each other? Must all organizations strive for a balance, or is specialization in exploitation or exploration for long-run success(Gupta, Smith and Shalley, 2006)? The purpose of this article is to summarize the relevant reterature and investigate the distinction and balance between exploration and exploitation.

DEFINITION OF EXPLOITATION

Exploitation was characterized as refinement, choice, production, efficiency, selection, implementation, and execution by March (1991). Its essence is the refinement and extension of existing competences, technologies, and paradigms. Its returns are positive, proximate, and predictable. March used code to represent a knowledge base of an organization and a interface for knowledge exchange between an organization and its member. He argued that individuals modify their beliefs continuously as a consequence of socialization into the organization and education into its code of beliefs, so that the knowledge of the organization can be exploited by its member. Rapid socialization of individuals into the procedures and beliefs of an organization tends to increase exploitation of the existing knowledge of the organization. However, it will reduce the level of knowledge reflected by the organizational code, since the organization need time to absorb the knowledge of individuals. Compared to returns from exploitation, returns from exploration are systematically less certain, more remote in time, so that most

of organization researchers assumed that organization tends to follow their routines, improve their existing capabilities, and squint to exploitation. In addition, there are many other factors drive firms to exploitative activities.

By reviewing articles in the research on managing exploration and exploitation, we find that the tendency of firms to exploitative activities can be attributed to three arguments: (1) When firms fall into some activities, the speed of reorganization may much lower than the rate at which environmental conditions change---the phenomenon is labeled "structure inertia" by Hannan and Freeman (1984). Inertia results from internal forces, such as irreversible managerial commitments and historic decisions, as well as from external forces, such as institutional legitimation (Hannan & Freeman, 1984). When the established routines and skills become embedded in decision-making processes and applied almost automatically in response to external stimuli, inertia will be intensified. (Lavie & Rosenkopf, 2006). Hannan and Freeman (1984) noted that inertia elicits accountable, reproducible, and reliable organizational outcomes and thus reduces uncertainty and variability in accordance with March's (1991) notion of exploitation. (2) In the face of radical technological change, the potential downfall of established firms has attracted a great deal of attention in research on technology management and organizational learning (Lee, Lee, & Lee, 2003). Once firms accumulate sufficient experience with one technology, it is natural for them to be trapped in the technology or to be blinded to alternative opportunities---this phenomenon is labeled "learning myopia" by Levinthal and March (1993). (3) A firm's current position in the industry is often shaped by the path it has traveled. Its previous investments and repertoire of routines constrain its future behaviors---This phenomenon is labeled "path dependency" (Teece, Pisano, & Shuen, 1997). The importance of path dependency is amplified where conditions of increasing returns to adoption exist. This is a demand-side phenomenon, and it tends to make technologies and products embodying those technologies more attractive the more they are adopted. Increasing returns to adoption has many sources including network externalities, the presence of complementary assets and supporting infrastructure, learning by using, and scale economies in production and distribution (Teece, Pisano, & Shuen, 1997).

DEFINITION OF EXPLORATION

Exploration was characterized as search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation by March (1991). Its essence is experimentation with new alternatives. Compared with exploitation, returns from exploration are systematically less certain, more remote in time, and often negative. March argued that organization absorb the knowledge of individuals and apply them in the activities of exploration. However, Rapid socialization of individuals into the procedures and beliefs of an organization may restrain individuals from being innovative and then negatively affect the level of knowledge reflected by the organizational code. The level of organizational knowledge reflects the abundance of the sources of the organizational innovative capability. If an organization want to increase its aggregate knowledge, it have to slow down the rate individuals socialized into it or to speed up the rate it learn from individuals. However, since there are no obvious individual incentives for learning slowly in a population in which others are learning, it is difficult to slow down the rate of socialization, for individuals, into the organization. Moderate personnel turnover will provide opportunities for an organization to acquire new knowledge. Especially, for mutual learning has a dramatic long-run degenerate property under conditions of exogenous environmental turbulence, moderate turnover can refresh knowledge of an organization.

Miller, Zhao, and Calatone (2006) extended March's (1991) model which include direct interpersonal learning and recognize knowledge has a tacit dimension that cannot be transmitted through codification. The extended model regarded the physical distance between people as one of important factors which affect the results of learning activities. The farther a learning target located, the lower the network density will be. Rapid distant learning will constraint the diversity of knowledge and slightly reduces the level of organizational knowledge after the balance was reached. Middle rate of local knowledge search is the most advantageous for the level of organizational knowledge. March's model use organizational code as a media for knowledge exchange. However, tacit knowledge can not be codified and be expressed by languages; March's model can not express the influence of tacit knowledge to exploration and exploitation. Interpersonal learning is the main mechanism for the exchange of tacit knowledge. Tacit knowledge will slow down the rate of learning of individuals, and the organization can learn from individuals with plenty of time, as well as reach a higher level of aggregate knowledge. However, the higher the ratio of explicit knowledge is, the more conspicuous the effect of length of learning cycle of individuals to the level of organization code. Usually, the detrimental effect of turnover on tacit knowledge may overwhelm any positive effect of moderate turnover on codifiable knowledge, even for very low levels. Miller and his coworker also found that the number of individuals will affect the diversity and the level of organizational knowledge. Simple knowledge allows faster accumulation of knowledge and higher proportion of correct beliefs than complex knowledge, one way to cope with complexity is to increase the number of individuals engaged in problem solving.

RELATIONSHIP BETWEEN EXPLORATION AND EXPLOITATION

March (1991) argued that both exploration and exploitation are essential for organizations, and compete for scarce resources. Maintaining an appropriate balance between exploration and exploitation is a primary factor in organization survival and prosperity. He and Wong (2004), in their empirical test to manufacturing firms, found that the relative imbalance between explorative and exploitative innovation strategies is negatively related to sales growth rate, while the interaction between explorative and exploitative innovation strategies is positively related to sales growth rate. According to Katila and Ahuja (2002), exploitation of existing capabilities is often needed to explore new capabilities, and exploration of new capabilities also enhances a firm's existing knowledge base. Exploration and exploitation form a dynamic path of absorptive capacity (He & Wong, 2004). In sum, exploration and exploitation are complement with each other, their interactive effect positively related to the growth of firms. However, firms may run into organizational difficulties when pursuing both strategies equally aggressively, causing the positive interaction effect to disappear (He & Wong, 2004). The causes need a further exploration.

Trade-off between exploration and exploitation

March (1991) argued that the resources deployment between exploration and exploitation is processes of both explicit and implicit choices made by organizations. The explicit choices are found in calculated decisions about alternative investments and competitive strategies. The implicit choices are buried in many features of organizational forms and customs, such as incentive systems, the way in which targets are set and changed, search rules and practices. For example, the shareholders may concern about maximum profits, while managers persuade growth of the firm. The trade-offs between exploration and exploitation are complicated not by the fact that returns from the two options vary with respect to their expected values, but also with respect to their variability, timing, and distribution within and beyond the

organization. Processes for allocating resources between them are also appeared concretely through intertemporal, interinstitutianl, and interpersonal comparisons, as well as risk preferences (March, 1991).

While researchers have normatively assumed that firms should seek to balance exploration and exploitation because both short-term productivity and long-term innovation are essential for organizational success and survival (March, 1991; 87), Lavie and Rosenkopf (2006) found that prescriptions about whether firms should strive to manage the trade-off between exploration and exploitation are inconsistent with observations about firms' tendencies to balance these activities in actual practice. They agued that it is because prior research examined exploration and exploitation within a single domain, disregarding the conflicting organizational pressures that influence learning in various domains. Accordingly, Lavie and Rosenkopf examined exploration and exploitation, in the context of alliances, within function, structure, and attribute domains simultaneously. They found that firms have different tendencies within the exploration-exploitation continuum in different domains which are complement with one another. For example, a firm that shifts its focus from R&D alliances to marketing alliances over time may intensify its search for new partners and thus balance increasing tendencies to exploit in the function domain with tendencies to explore in the structure domain. Lavie and Rosenkopf also found that while explorative and exploitative activities within every domain are affected by path dependency, firms strive to adjust their policy toward the opposite direction over time and balance exploration and exploitation across domains. Their study reminds researchers to observe the tendencies of firms between exploration and exploitation from different perspectives to avoid depicting only a partial picture of firms' balancing efforts.

Interaction between exploration and exploitation

Most researchers agreed with the perspective of March (1991) and believe that exploration and exploitation are the two ends of a continuum and compete with each other for the limited resources within an organization (Ozsomer & Gencturk,2003; Lee, Lee, & Lee,2003; Holmqvist,2004; Auh & Menguc,2005; Miller, Shao, & Calatone,2006; Perretti & Negro,2006; Lavie & Rosenkopf,2006). However, the other researchers argued that some resources are unlimited, such as knowledge, information, and external resources (McNamara & Badden-Fuller, 1999; Benner & Tushman,2003; He & Wong,2004; Cesaroni, Minin, & Piccaluga,2005). They believe that there is no contradiction between explorative and exploitative activities---The phenomena are labeled "orthogonality" versus "continuity" by Gupta, Smith, and Shalley (2006). The former believe that firms make decision for the ratio of resource allocating to explorative and exploitative activities according to the strategic position, they chose, within the continuum, while the latter believe that explorative and exploitative activities are complement with each other. Researchers, who believe that exploration and exploitation are two different and orthogonal aspects of organizational behavior, note that firms may acquire external resources by engaging in alliances, mergers, and acquisitions. Cesaroni, Minin, and Piccaluga (2005) observe firms' behaviors under the situations where technological changes are incremental or fairly rapid. They found that when technological change is fairly rapid and the dominant technology is not formed, focusing on R&D activities or looking for technological cooperation my help firms to survive. On the other had, when technological change is incremental and the firm is short of complementary asset, it can use its alliances' assets to exploit the outcome of its innovation.

Some researchers who supported the concept of "structural ambidexterity" argued that the characteristics of functional departments in an organization are different and need to be governed by different ways. For example, the core business units are given responsibility for creating alignment with the existing products and markets, while the R&D department and business development group are given the job of

prospecting for new markets, developing new technologies and keeping track of emerging industry trends. Structural separation is necessary because the two sets of activities are so dramatically different that they cannot effectively coexist (Benner & Tushman, 2003; Cesaroni, Minin, & Piccaluga, 2005; Gupta, Smith, & Shalley, 2006; Geiger & Makri, 2006; Miller, Zhao, & Calatone, 2006).

THE AMC CASE

AM Company (AMC), founded in 1990, is a multinational corporation in the design and manufacture of multimedia, presentation and network video products with a Headquarters in Taiwan. AMC is currently the leading manufacturer of TV turners, PC-to-TV converters, document camera and security DVRs with a high reputation which received numerous prestigious awards from PC Magazine, CHIP, PC World, Presentations Magazine, Computex Show and Consumer Electronic Show (CES). To maintain its business relationship, AMC has established a strong connection with its national distributors, retailers, e-tailers, mail-order resellers and value-added retailers (VARs). In addition to 3 major categories, AMC tries to extend its product line to Digital Video Maker, TV Photo Viewer, and an even wider range of unique presentation, security and multimedia items with a challenging goal to be the top 3 in the world market. Therefore, almost 11% of sales revenue is invested in the research and development for new products. The worldwide offices are also set up in the USA, UK, Spain, Germany, French, Thailand and China to be close to the market.

AMC is committed to enriching entertainment experience and promoting effective communication among people with the following philosophies: (1) Being down to earth: to stand on solid ground and practice its fundamental work in practice ways, and to focus on its core business as one of the global leaders in the related field. (2) Creating Value: to encourage innovation and enhance long-term business value in addition to short-term profitability. (3) Contributing to community: to be dedicated to improving people's life quality with team work. (4) Serving People: to create profit and share with stakeholders. With 15 years of experience in the multimedia industry, AMC have 250 R&D engineers accounted for 30% of employees in the research and development of products. In order to gaining competitive edge, AMC chooses a strategy with both developing own brand and soliciting ODM business.

AMC launched VGA-Aver as the first user-affordable video overlay in Taiwan and the 3rd in the world in 1990. AMC introduced AverKey3, the first PC/Mac-to-Video Converter with Remote in the world in 1994, By using its core competence, AMC expanded its core technology from converter to 'bridging PC and Video'. After the product of digital TV is successfully developed, it brings about a potential market between PC and TV industry. AMC obtains the ISO9002 certification in 1996, ISO9001 in 1997, ISO14000 certification in 2004, and wins the awards of Taiwan Excellent Awards, 2006 Taiwan Superior Brand and Best Choice of Computex Taipei 2006…etc. The outstanding R&D team enables AMC to explore advanced technology and make a breakthrough in new product development.

Meanwhile, in order to take advantage of the economics of scale and the existing core technology, ODM business also plays an important role in AMC. The major clients such as Toshiba, NEC, Sony covering over 50% market share in Japan and Dell in the USA procures a large quantity in multimedia products. All strategic alliances get involved in the early stage in new product development process and request a high standard in production efficiency as well as cost reduction. Due to different specification requirements for each client, AMC has to provide a specific product design and offer a unique

production system by quick mold change and line switch for daily output. In conclusion, the exploitation concept is the first priority for ODM business in AMC (Tsai, 2006).

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The Study of Key Success Factors of Incubators in Taiwan: The Analytic Hierarchy Process (AHP) Approach

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Abstract

The Incubation center has been established and well performed in the country such as the U.S.A. for many years. The first incubation center was set up in Taiwan in 1996.Taiwan has established more then 95 incubation centers across the island by combining the knowledge and R&D capacity of the government, academic institutions and private sectors over the past 10 years. However, due to the rapid changing environment and shrinking budget, the incubation center has encountered a severe challenge in the year to come. The purpose of this study would first analyze the status of all incubators in Taiwan and then figure out their key success factors for their future management.

In addition to in-depth interviews and archival review, the Analytic Hierarchy Process Approach will be carried out in the study. The finding of ten key success factors is shown as follows:

1. To set definite goals for organizations
2. To solve problems Immediately for entering and being stationed enterprises
3. To set up clear policies
4. To assist in technology transfer and invention
5. To choose excellent entrepreneurial teams deliberately
6. To select unique industry for entering and being stationed enterprises based oncore resources of mother organizations
7. To provide management knowledge as well as legal knowledge
8. To encourage faculty and students to create entrepreneurial opportunities
9. To hire managers with spirit of entrepreneurship
10. To keep good social networks in mother organizations

For achieving successful management of incubators, the incubation managers have to master the above ten key success factors. Accordingly, that performance of incubators can be totally expected, limited resources can be effectively allocated and exercised. Meanwhile, the managers' practice and workload can be simplified. Moreover, the ten key success factors can be further used as the criteria to evaluate the management system for incubation centers.

Keywords: incubator, key success factors, Analytic Hierarchy Process

INTRODUCTION

Nowadays, for the small and medium enterprises to start their business, the incubator is an important institute that plays a crucial role in resolving the problems of the small and medium enterprises. The incubator provides the operation space, business service, technology support, and the administrative assistance to the business pioneers during the initiating stage, so the new business or owners with skills can reduce the operating costs and risks efficiently and the initiative can receive the assistance for development and advancement in order to have the better chance to success (Lai, 2002)[1]. In other words, the incubator is not only responsible for cultivating the emerging hi-tech enterprises in Taiwan but also the essential tool to help the local industries to prosper..

Currently, most of the initiative incubators in Taiwan are hosted in the academic institutions. The main reason is to reduce the costs of purchasing facilities and requirements by effectively utilizing and sharing the existing software and facilities in the universities. Moreover, the cooperation between the industry and the

academia would bring successful technology transfer that helps the hi-tech small and medium enterprises to initiate the business. 83% of the total incubators in Taiwan are affiliated to the universities and colleges. The academic incubators can substantially benefit the cooperation between the industries and the academia, the advancement and transformation of the industry, and the development of the local industries. (Small and Medium Enterprise Administration, 2003) [2]

During the past decade, some practical experiences and conclusions abroad have already indicated the ways to run a good incubator. In contrary, it is only 8 years since the first incubator is founded in Taiwan, Moreover, during this time the incubator encountered the pressure from the drastic change of the external environment and the decrease of annual governmental grants, resulting in the revolution and challenges to the management of the incubator. Therefore, one of the motivations in this research is to analyze the current status and the future direction of the incubators in Taiwan.

As the number of incubators in Taiwan is growing steadily, it is hard to survive in the high competition without a clear orientation or unique features. Huang (1993) [3] proposed that the key success factors are the combination of the most important competences or assets for the industry, and a company should control these key factors to form the durable superiority. Otherwise, without holding to the key success factors, even a company has great strategies; it cannot fully perform with its competence.. Therefore, it can be said that the key success factors are the directions of the enterprises in this competition. The second motivation of this research is to find out the key success factors of the incubators in Taiwan.

LITERATURE REVIEW

The definition and functions of the Incubator

The term “incubator” literally means the culture plate, the incubator for premature infants, and the egg warmer. The egg warmer or the incubator for premature infants can make a fragile new life to grow up steadily and stably, which meets the function and meanings of the initiative incubator. The function of the incubator is not only for cultivating emerging industries but also for assisting the development of the local small and medium enterprises. The concept of the incubator has called an international attention in countries such as the Unite States, France, Germany, Sweden, Britain, Japan, and China. In addition to the name of the “incubator”, it can be also be referred to as “business incubation”, “innovation center”, “enterprise center”, “enterprise house”, “business and technology center”, “hatching grounds”, “hives”, “nurseries”, “support center”, and so on.

Yuan (1996) [4] suggested that in terms of the functions, the incubators combine the universities and colleges with the local environment, to develop the technology, spread the knowledge, and create the opportunity of employment and investment, thereby advance the economy of the country as well as the local areas. In terms of the management, the main mission is to excite the initiative of the industrial technology, to provide the training opportunity for the scientists and engineers, and to upgrade the R&D ability, product designs, and the productivity in order to cultivate the managerial ability of the small and medium enterprises.

The initiative incubator is an efficient innovative system to increase the possibility of success and to reduce the risks of operations (Hung and Lai, 1998) [5], Culp (1996) [6] indicated that the successful rate of the enterprises in the incubators is as high as 86.2%. Therefore, the incubator is considered as the effective system for the initiative business, which can assist the small and medium enterprises to reach the goal of technology advancement.

Key success factors (KSFs) of the Incubator

Generally speaking, the key success factors (KSFs) focus on the relationship between the industrial characteristics and the enterprise strategies. It is a widely accepted concept that KSF is to combine the competence with the crucial requirements in the environment, especially the industrial environment, in order to have great performance (Andrews, 1971[7]; Hofer and Schendel, 1978[8]). Most of the industries have 3 to 6 key success factors, and a company should pay extra attention to including these key factors into its competence in order to succeed in the industry. In other words, the KSFs concept becomes the important guideline for the design of a company’s information system and the design of the information system is also incorporated in the application of the management.

In the previous studies, several views on the KSFs of the incubators have been proposed. For example,

Smilor(1987) [9][10] targeted at the incubators and proposed 10 KSFs that are influential to the management:1.the knowledge of business and management;2.the financial consultation of the capital financing;3.the internal service support;4.the full support from the community;5.the business network of the local areas;6.the development of the education of the enterprise's technology and capability;7.the visions and insights;8.the appropriate enterprise policies;9.the cooperation and network with the R&D organizations;10.the clear plans and explicit policies and procedures. However, Steffens (1992) [11] thought that the management of the incubator should take notice of the following four points: 1. incubators take time; 2. looking to the bottom line; 3. don't stint on financing; 4. location, location, location.

In a more recent Taiwan-based study, Lee (1998) [12] concluded that the technology initiative incubators have the following KSFs. : 1. The central background, goal, and policy: If the incubator has a longer history, a bigger size , and it aims at the technology transfer, then it is more likely to succeed.; 2. the operator and the supporter: It is beneficial for the incubator if the affiliated institutes of the universities can provide the leisure facilitie.; 3. the types of the enterprises and the standards for admission: It is better to qualify the companies with diversity, technopreneurship, and the potential; 4. training service: It can benefit the management of the incubator by providing the office service and the R&D procedures and assisting the alliance and cooperation of technology between enterprises.

Kuo (2001) [13] believed that the KSFs should include the following seven points: 1. the clear missions and objectives of the operation; 2. the recruit of excellent professional managers and the business management of the incubator; 3. the service and assistance for the enterprises in the incubator; 4. the possibility research and operation plans for attracting investors; 5. a board that can carry out the promises and objectives and assist to promote the competence; 6. the sustainability of the financial capability for 3 to 5 years; 7. the support from the shareholders and the development of the internet incubator.

METHODS

Overview

The research was conducted in the following sequence. Firstly, based on a comprehensive literature review on the past research internationally and domestically, we proposed a working draft of the KSFs for Taiwan's incubators. Secondly, the draft will then be discussed and modified by the experts via the in-depth interviews, with the intent to obtain good evaluations about the KSFs in the draft. Thirdly, the draft will then be finalized and put into a formal questionnaire to be distributed. , Finally, the returned questionnaires would be analyzed through the the method of AHP and thus the final KSFs can be identified.

RESULTS

Analysis of Level 2 KSFs

Table 1: Comparison matrix and weight table of Level 2 KSFs

Level 2		F_1	F_2	F_3	F_4	F_5	Level Weight	Order
Resource	F_1	1.0000	1.0584	0.8827	0.8463	0.6307	0.1719	4
Service	F_2	0.9448	1.0000	1.8077	1.4223	1.1161	0.2411	1
Screening System of Companies	F_3	1.1329	0.5532	1.0000	0.6093	0.8229	0.1567	5
Strategy	F_4	1.1816	0.7031	1.6412	1.0000	1.0845	0.2136	3
Goal and Management	F_5	1.5855	0.8960	1.2152	0.9221	1.0000	0.2168	2
$\lambda_{max} = 5.0802$ ， $C.I. = 0.0201$ ， $C.R. = 0.0179$ ， inconsistency=0.02								

As shown in Table 1, all the operators of the incubators consider that "service" is the most important factor, and then followed by "goal and management", "strategy", "resource", and "screening system of companies".

The analysis shows that the first factor in order is "service". As well as general enterprises, the incubators cannot recruit companies without satisfactory services. The second important factor is "goal and management", which means that the clear goals and policies are second to the service in the operation of the

incubators. “Strategy” is ranked in the third place, indicating that a good strategy needs to be based on an important goal. The forth one is “resource”, which is the source of the superiority. “Screening system of companies” is the fifth factor and it is the guideline for the incubators to choose the appropriate companies. It can influence the possibility to success of the companies and the performances of the incubators.

Analysis of Level 3 KSFs

As listed in Table 2, the Level 3 factors are classified into five main Level 2 categories including resource, service, screening system of companies, strategy, and goal and management. Following the same procedures of calculation and analyses, the comparison matrix and weight of each success factor are discussed with respect to each category.

Resource

Table 2: Comparison matrix and weight table of Level 3 factors--Resource

Level 3		F_1	F_2	F_3	F_4	F_5	Level Weight	Order
Capability of technology innovation and commercialization	F_1	1.0000	1.4789	0.7869	0.7837	0.6794	0.1785	4
Good management system	F_2	0.6762	1.0000	0.5956	0.6656	0.7218	0.1414	5
Managers with entrepreneurship	F_3	1.2708	1.6790	1.0000	1.1715	1.1715	0.2435	1
Good relation with the parent institutes	F_4	1.2760	1.5024	0.8536	1.0000	1.3427	0.2299	2
Business operating ability	F_5	1.4719	1.3854	0.8536	0.7448	1.0000	0.2068	3
$\lambda_{\max} = 5.0287$ ， $C.I. = 0.0072$ ， $C.R. = 0.0064$ ，inconsistency=0.01								

According to the analysis of resources, “managers with entrepreneurship” is the first in the rank with the percentage of 25%. It shows that the managers are the main human resource in the incubators, and as Druker (1995) [14] said, the managers with technopreneurship can run the initiative business or adopt new approaches to create new profits with the existing resources. As a result, the technopreneurship makes the managers of the incubators can identify every opportunity to integrate resources and to make profits, so the companies can achieve the goals of initiating business and innovation and they can share the profits with the incubators at the same time.

“Good relation with the parent institutes” is ranked in the second place, showing that the academic incubators need to keep a good relationship with the parent institutes to integrate the resources of the professors, graduates, and administrative staff for better use.

Service

Table 3: Comparison matrix and weight table of Level 3 factors--Service

Level 3		F_1	F_2	F_3	F_4	Level Weight	Order
Assistance of technology transfer and development	F_1	1.0000	1.7870	2.4532	0.8620	0.3107	2
Knowledge of the business operations and law	F_2	0.5596	1.0000	2.6485	0.4724	0.2038	3
Service of office resource	F_3	0.4076	0.3776	1.0000	0.2780	0.1013	4
High speed of resolving problems	F_4	1.1601	2.1169	3.5971	1.0000	0.3842	1
$\lambda_{\max} = 4.0429$ ， $C.I. = 0.0143$ ， $C.R. = 0.0159$ ，inconsistency=0.02							

As shown in Table 3, the analysis of service rates “high speed of resolving problems” as the first important factor with the percentage of 40%. It is believed that the companies have to face the pressure of quick innovation and commercialization and the problems of operations, so they are desperate for the quick resolution from the incubators in order to have a better chance to success.

The second is “assistance of technology transfer and development” with the weight of 30%. The incubators help the companies to do researches and developments and to transfer technology through the cooperation between the industry and the academia. The technology transfer is a key factor for breakthrough. With the technology, the companies can develop the products and graduate from the incubators smoothly.

Screening System of Companies

Table 4: Comparison matrix and weight table of Level 3 factors-- Screening system of companies

Level 3		F_1	F_2	F_3	F_4	Level weight	Order
Excellent initiative teams	F_1	1.0000	3.7725	1.8143	1.7662	0.4325	1
Good operation projects	F_2	0.2651	1.0000	1.1010	1.0231	0.1714	4
High potential of rapid growth	F_3	0.5512	0.9083	1.0000	0.7925	0.1841	3
Sufficient capital	F_4	0.5662	0.9774	1.2618	1.0000	0.2120	2
$\lambda_{max} = 4.0860$ ， $C.I. = 0.0287$ ， $C.R. = 0.0319$ ，inconsistency=0.03							

As shown in Table 4, the most important factor is “excellent initiative teams”, with the percentage of 43%.The establishment of a business cannot be done by oneself, and instead, it needs the participation of more than two people with sufficient capital, managerial capability, and unique technology. Therefore, an excellent initiative team can affect the success of the incubator.

The second is “sufficient capital”. The capital is the life of the initiative business, so sufficient funds can be the factor to success.

Strategy

Table 5: Comparison matrix and weight table of Level 3 factors--Strategy

Level 3		F_1	F_2	F_3	F_4	F_5	Level Weight	Order
Selecting the unique industry with the core resource of the parent institutes	F_1	1.0000	2.8594	2.0608	1.8268	0.9174	0.3044	1
Enhancement of the business extension and promotion	F_2	0.3497	1.0000	1.1894	1.2392	0.8041	0.1614	4
Recruiting knowledge-based or development-based service companies	F_3	0.4852	0.8408	1.0000	1.5085	0.9974	0.1746	3
Promotion of the strategic alliance of the incubators	F_4	0.5474	0.8070	0.6629	1.0000	0.7247	0.1412	5
ent to the staff and students for the initiative business	F_5	1.0900	1.2436	1.0026	1.3799	1.0000	0.2183	2
$\lambda_{max} = 5.1176$ ， $C.I. = 0.0294$ ， $C.R. = 0.0263$ ，inconsistency=0.03								

As shown in Table 5, the most important factor regarding strategy is “selecting the unique industry with the core resource of the parent institutes”, with the percentage of 30%. According to the interviews, every incubator targets at different fields, and based on the core resource of the parent institute, it integrates the resources for teachers and students to select the unique companies in certain fields. By doing so, it can centralize the core capability of the incubator to overcome the obstacles of cultivation and economy of scale in the operations and it will be easier for the incubators to success.

The second factor is “encouragement to the staff and students for the initiative business”. Smilor (1986) [15] pointed out that one of the ten success factors for the incubator is to maintain the close relationship with the universities and colleges. Therefore, the school staff and students who participate in the programs of the incubators can meet with the pioneers and acquire the first-handed practical experiences of developing new business and products. The benefit is to allow the students find a job much faster than those who do not have the experiences, or to collaborate with the teachers to initiate business, thereby achieving the goal of innovation and initiative.

Goal and Management

Table 6: Comparison matrix and weight table of Level 3 factors—Goal and management

Level 3		F_1	F_2	F_3	Level Weight	Order
Clear organizational goals	F_1	1.0000	1.1235	2.5623	0.4276	1
Explicit policy	F_2	0.8901	1.0000	3.1062	0.4219	2
Comprehensive management system of the incubator	F_3	0.3903	0.3219	1.0000	0.1505	3
$\lambda_{max} = 3.0106$ ， $C.I. = 0.0053$ ， $C.R. = 0.0092$ ，inconsistency=0.01						

As shown in Table 6, the most important factor in the analysis of goal and management is “clear organizational goals”, with the percentage of 42%. According to the observations of the research, every

incubator has a main goal, which decides the developing direction and the general goals including the cultivation of new business, creation of employment opportunity, commercialization of new technology, recovery of the local economy, and the promotion of technology transfer.

The second in the rank is the "explicit policy". In order to achieve the goals, the incubator has to possess the explicit policies, such as the feedback policy and the graduation policy. An explicit policy allows the companies to have appropriate expectations to the development of the incubator.

CONCLUSION

According to the analysis of the AHP structure, there are five perspectives of the KSFs for the academic incubators in Taiwan. The five perspectives include "service", "goal and management", "strategy", "resource", and "screening system of companies" , stated in the order of importance.

To find out the top ten KSFs across all perspectives, we decided to select the top two factors from each perspective to form the final ten KSFs stated in the order of importance: ,

1. Clear organizational goals
2. High speed of resolving problems
3. Explicit policy
4. Assistance of technology transfer and development
5. Excellent initiative teams
6. Selecting the unique industry with the core resource of the parent institutes
7. Knowledge of the business operations and law
8. Encouragement to the staff and students for the initiative business
9. Managers with entrepreneurship
10. Good relation with the parent institutes

Based on the AHP analysis, it is believed that the success of the incubator lies in the managers to control the ten factors. With these KSFs in hand, the managers can dominate the entire operations. If the managers can effectively allocate and distribute the limited resources, the workload of the managers can be simplified and the managers can detect whether the operation can be a success or a failure.

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TAIWAN'S DEFENSE GOVERNANCE IN THE ERA OF GLOBALIZATION

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ABSTRACT

This paper attempts to investigate issues on Taiwan's defense governance including ideas and concepts, adjustment and adaptation, and the possible strategies in the process of globalization. Steven Staples (2001) indicates that the composition of the defense governance includes defense economy, internal defense relations, and external defense interactions. In the meanwhile, according to the French National Research Institute, the concept of the defense governance contains five components: national defense key factors, national defense principles, defense economy, defense structure, military mission and defense will power. This study examines the above-mentioned definition and proposes to apply the French model to review the state-of-the-art in Taiwan's defense governance. It is believed that public participation and social support are the most crucial elements in reaching a consensus that will support the establishment of Taiwan's unique defense governance.

Key words: Defense governance, Globalization

Introduction

Globalization originates from the changes in economy and economy has a decisive influence on politics. The great influence of politics on the military thus leads to political and military globalization. This study mainly focuses on the changes of the defense governance in the Republic of China in the era of globalization, the ways to cope with the influence of globalization on the national defense security, and the laws to promote the defense security. With the popularity of globalization, military globalization has also become an important issue and will thus plays a role in the national defense security.

Globalization and Military Globalization

In the globalized international society, national and personal security remain the main concern, but collective security, regional security, and even the global security have also to be our concern. This inseparableness makes the international situation more complicated (Wang & Lee, 2003: 33-34). On the one hand, globalization has caused instability, insecurity, inequality, conflicts, and even wars. To control the possibility of war, the international society is also thinking about how to stop war from happening. Thus, globalization has brought about a tricky situation: the proliferation of weapons has increased the possibility of war, whereas the international society has developed a format for security governance. This phenomenon has already influenced the defense policies of some countries (Want & Tsai, 2003: 44-45).

Military globalization is mainly based on technological development. The technological development makes it possible for the military globalization not only to happen but also to be highly advanced, offering the military globalization stronger basis to develop (Yao, 2004). After the 911 terrorist attack, the United States based its military globalization on anti-terrorism, especially on security governance and regional defense governance (Wang & Tsai, 2003: 52-53).

In the military theory, the military goal lies in the fact that while adopting new weapons, it is necessary to raise the will power. That is to build intangible psychological power to fight against the enemy's tangible military power. In the civil front, it is essential to develop a popular sense of crisis. It is one of the driving forces to carry out defense governance (Wang & Tsai, 2004: 60-61). Furthermore, the concept of national security has shifted from traditional military security to comprehensive security. Therefore, defense governance becomes a technique that integrate the resources of the people, government, military to achieve the national strategic goals.

Military globalization has a tendency to expand geologically. It surpasses the boundary of

politics and has involved more and more countries. The special nature itself of the military often contributes to conflicts and interdependency between countries. To avoid conflicts and to control weapons proliferation, human society has laid out the global affairs, mainly in two ways: First, to design a format for defense governance, and second to gradually establish common rules for all the military establishments on a basis of communication.

Meanings and Elements of Defense Governance

Governance is a combination of different ways to deal with matters in various kinds of private or public organizations. It includes official agencies and laws that can force the public to obey and it also includes unofficial arrangements. All these organisms are established with the consent and in the interests of both the public and agencies (Strange, 1995: 203).

The so-called defense governance is to govern the resources shared by all groups within a country for the good of strategy. Therefore, in terms of economics, it is the relationship between "demand and supply" or "inputs and outputs" (Wang & Tsai, 2003: 52-53). As indicated in Illustration 1, defense governance includes defense economy and internal and external defense relations. Internal defense relations include defense laws, military policies, and military & civil relations. External defense relations refer to national security and foreign relations (Wang & Tsai, 2003: 54).

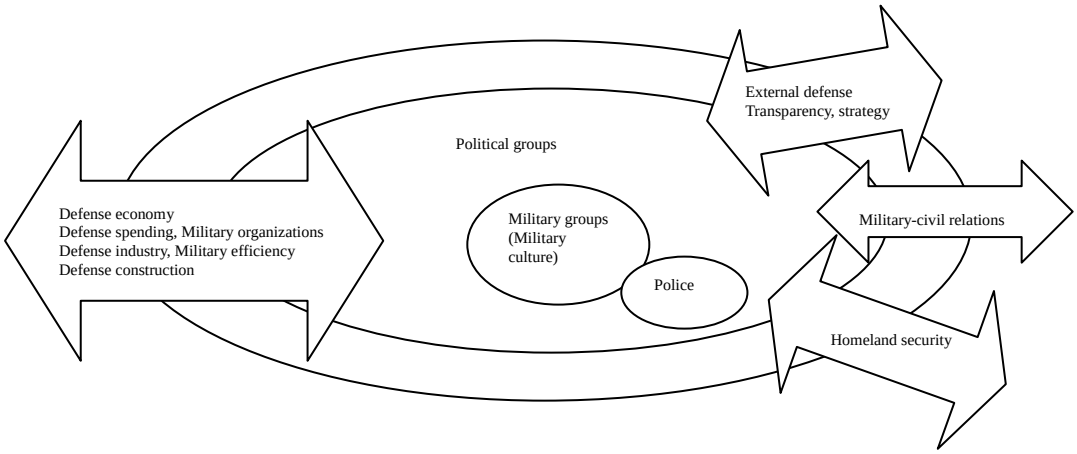


Illustration 1: Elements of Defense Governance
Source: Staples, 2001: 43; Wang & Tsai, 2003: 54

Table 1: Contents of Defense Governance

Defense Economy Such as military expenses, defense industry, military organizations, efficiency related defense enterprises
Internal Defense Relations · Internal security implementation: including defense relations regarding internal laws and orders, the separate relation between military policies and politics. · Military and Civil relations: the role the military play inside the government, how the government control the armed forces, the interaction between the military and the mass · Defense industry in commerce: including the role officials from defense industry play in the military decision making and its commercial interest
External Defense Policy Implementation · Transparency: make public the purpose and form of the military strategy · Security relations: bilateral and multilateral security commitments

Source: Wang & Tsai, 2003: 54

Lai (2006) listed the key factors of the French defense policies in his class handout at The Graduate School of Strategy of Tamkung University in Taiwan :

1. Defense key elements: a. Security analysis b. Military threat assessment c. Fundamental interest of defense security policies, such as the protection of land, people, sovereignty, and the safeguard of fundamental national value.

2. Defense principles: the defense philosophy, strategy culture, military thought, tactics, and battle guidelines.

3. Defense organizations: Including all units of the armed forces, all that can be mobilized to battle or to support battles, the ratio of the armed forces, and recruiting system.

4. Defense missions: a. Tools (equipment to carry out missions)—everything involved in defense equipment policies. Except for a few countries such as the United States and Russia, most of the countries are not self-sufficient in the military equipment. Therefore, the major powers (NATO) in Europe has started to think about cooperation an integration. b. Missions—Defense policies must consider in advance future war, budget, and national economic development, establish long-term main defense philosophy, and regularly (every one to four years) review and adjust defense equipment. The life expectancy of equipment is fifty years, so "be ready" for tomorrow's war at any moment.

5. Defense will: Defense demands high-quality intelligence of the people, understanding national situations and defense affairs, support for defense policies and construction, and a sense of identity and willingness to defend the country. Because of the increasing precision, capability, and costs of the weapons, the major goal of a war will be changed into focusing on striking the enemy's key points in order to destroy its defense will. See Illustration 2:

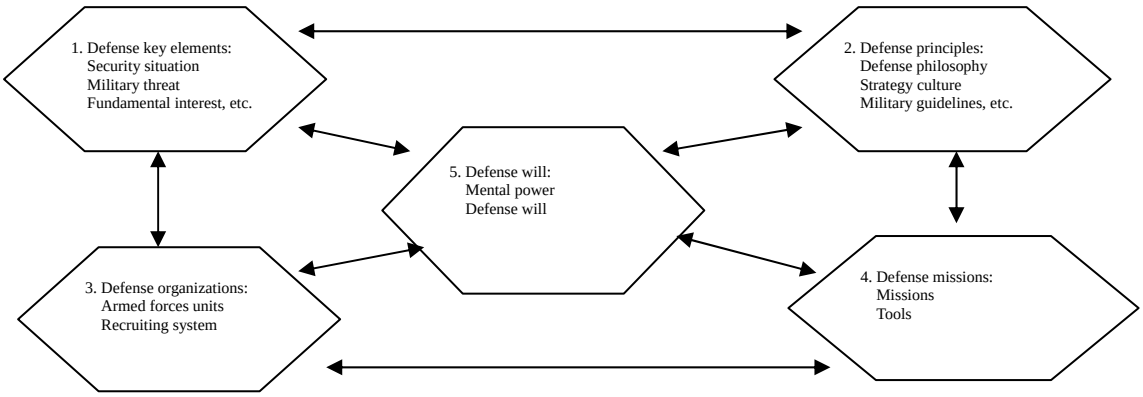
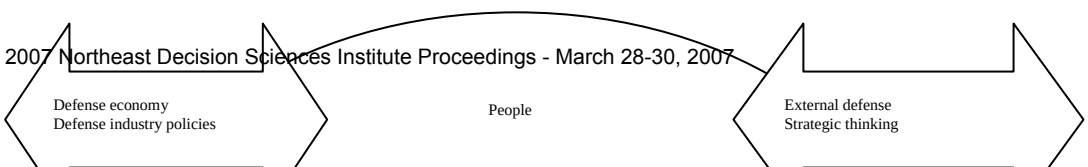


Illustration 2: Five Elements of French Defense Policies

Source: Institut des Hautes Etudes de Defense Nationale 1999 Comprendre la Defense, Economic, Economica, Paris, France. Quoted from Lai's class handout.

This study builds its concept structure by combining the key points from the two above-mentioned theories with the current situation of the ROC. Influenced by the international relations, the military equipment policies mainly depend on foreign powers. Thus, the defense independence is seriously limited, an issue worthy of study. After the implementation of the National Defense Education Act on February 2, 2006, the government can develop its defense intelligence from the ordinary citizens. This will greatly help in the efforts to enhance the understanding of the public for the defense and to strengthen the defense will. Therefore, this study finds its theoretical foundation by adapting the contents of the Illustration 1 and adding "defense industry policies" and "people's defense will" into them, which is shown in Illustration 3.



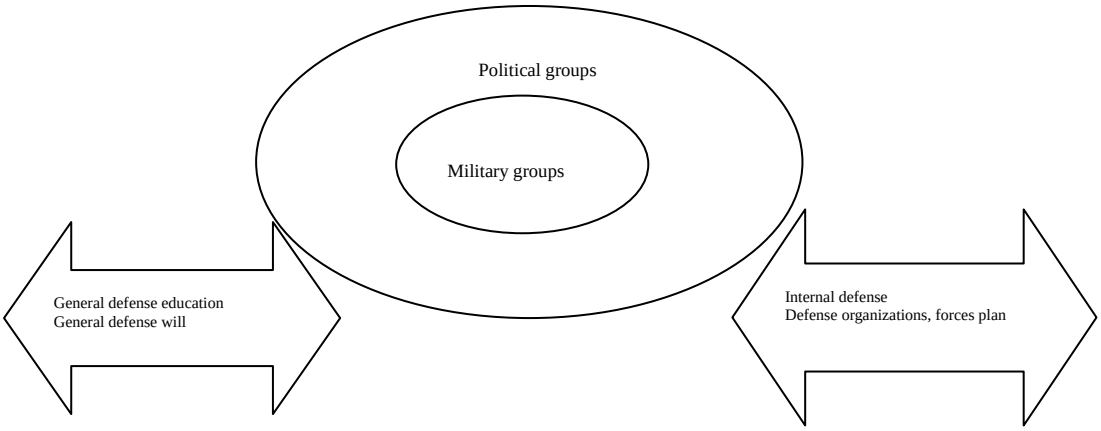


Illustration 3: Elements of Defense Governance of the ROC
Source: Adapted by the writer from Illustrations 1 & 2

Globalization and National Defense Strategies

In military security, the new realism believes that for the interest of a country power, security and survival are the most important considerations. Therefore, military power is the most important one. However, new liberalism insists that thanks to the gradual ease of international relations, the military threat has reduced. Thus, the importance of military power has been significantly lowered and the international cooperation area has been clearly expanded. In economy, though both emphasized the importance of economy factors, new realism thinks that a nation has to depend on its own power to maintain its status in the international community. New liberalism, however, believes that international economic interest is as important as national security (Chang, 2002: 44-45).

The ROC's national security policies, defense policies, and military strategies have long been based on the idea that a nation should build its military power in the people, integrate the efforts in peaceful times and those in war times, take effective preventive measures, take effective defense, involve the public in defense, and build a total defense system. In practice, those ideas are incorporated into defense strategies: "The defense warfare of the ROC is based on the strategies of "effective preventive measures" and "effective defense" (National Defense Report, 2003). Under the military globalization, the defense policies and development of military strategies are deeply influenced by China, the United States, and Taiwan's geologically strategic position.

From China's viewpoint, since the beginning of its "open policies" in 1978, "peace and development' has been its focus in its national strategies. Though everything is centered on the economic development, it also emphasizes the importance of defense construction. Especially after the post-cold war, "the theory of China's threat" has become a major issue in the international community. Therefore, China has to put more emphasis on the building of its military power. On the one hand, it continues to modernize its military. On the other hand, it speeds up its efforts in international strategic peace. Basically, the purpose for China to propose the "rise of peace" theory is to win the strategic chance period of at least 20 years.

For the United States, there has been a tough issue to handle. On the one hand, it continues its "One China" policy. Politically, it assures China that it will not damage China's national interest. On the other hand, it keeps selling weapons to Taiwan by the Taiwan Relations Act. At the same time, it asks both Taiwan and China to follow the same principle, "China promises not to invade Taiwan by forces, Taiwan guarantees not to seek independence, and both sides agree to hold peace talks and negotiations." In recent years, the United States has strengthened its military deployment in the Asian-Pacific area and the practicality of the US-Japan Security Treaty and the US-South Korea Combined Defense Treaty. Besides, the advance deployment of the US military forces at Guam indicates that the US has no confidence in Chinas' economic and military development. In the future,

Taiwan will play a strategic role in restrain China from expanding to the oceans and breaking the first island chains.

With the second-generation reconstruction and the development of defense technology, the ROC military, besides adjusting its structures, needs to build strategy construct that is in line with the current situation between the two sides of the Taiwan Strait and the international situation. The ROC military has undergone five changes for its strategy construct since 1949 to become the current defense-oriented one (See Table 2). It is believed that the ROC strategy should not alienated itself from the global trend. Globalization may bring change to Taiwan, and it may also influence the peaceful change for China. However, the ROC's defense security cannot wishfully depends on China. It must have its own well-advanced thinking and plan, designing its counter-strategies in dealing with the possible crisis in the Taiwan Strait.

Table 2: Changes of the ROC Defense Strategies

Defense consolidation (1949-1959)
Anti-Communism and War Readiness (1960-1978)
Combination of Offense and Defense (1978-1990)
Defensive consolidation (1991-2001)
Effective intimidation & Defensive consolidation (2002-)

Source: Excerpt from the ROC Defense Report, 2003

National Defense System and Military Structure under Globalization

In the era of globalization, national security has gone from the narrowly-defined military security to the broadly-defined multidimensional view of security. That is, it contains comprehensive sectors: national defense, diplomacy, relationship between the two sides of Taiwan Strait, finance & economy, technology, psychology, environment, and crisis management. The purpose of the ROC national security policies is to safeguard the country's comprehensive security.

Huntington divides the defense system into three models: balanced model, Coordinated model, and vertical model (Huntington, 1957: 186-189). Based on the new Defense Structure Act, the ROC's defense system is more similar to the vertical model. It includes the Defense Department, the National Security Council, and the Executive Yuan. It seems that the system needs more coordination and cooperation in makes strategies (Lee & Chen, 2006: 18-19).

Under the increasing threat from China, the ROC military completed its reconstruction for air superiority and part of sea superiority in the years from 1993 t0 2002. Currently it focuses on the readiness of the C_4ISR system, the reconstruction of missile defense system and sea superiority in order to achieve the strategic goal of "effective intimidation" and "defensive consolidation" and to maintain the balance of the military power between the two sides of the Taiwan Strait (Defense Report, 2003).

Globalization and National Defense Industry Policies

Globalization is in irreversible trend, so the globalization of the defense industry can not be neglected. It will have significant influence on world politics, economy, and military innovation. Under the current conflicting situation between the two sides of the Taiwan Strait, the military has to adjust its strategies and renovate its equipment, in order to build up a force with limited number, excellent quality, and strong power.

Since defense industry is a huge investment, it may cause a heavy financial burden for the country. Therefore, the defense policies have to incorporate the efforts from the private sectors to develop defense industry with its priority on self-sufficiency in producing military equipment (Chang, 2005: 47-48). Defense expenses and economic development do not necessarily have to conflict with each other (Tseng, 2002).

In the military innovation, the military core power is the key to maintaining military competition edge. The independent development capability in the defense industry is one of the core powers. Under the influence of globalization, it is too costly for a country to develop its own defense industry. Only through the corporation with the private sectors can the defense industry develop new techniques that can be used by both the military and the private industries.

Globalization and General Defense Will

The coming of globalization and post-cold war has changed the traditional human understanding of security. It also means the changes of global security situation and strategy models. Since the terrorist attack in 2001, the types of war and conflicts have changed. However, the will of any country to safeguard its security is never changed. National security can be guaranteed not through the military force only, but through the building of a common will of general defense. It is necessary to teach the public to be involved in national defense. This way, the total national power can be enhanced, and national security can be strengthened.

Conclusion

Defense governance under globalization is multidimensional. Defense security is carried out not by a any single person but by all the citizens. Therefore, it is urgent to increase the understanding of the country and the national defense. Globalization does not eliminate the conflicts between countries, but it does increase the dependence between countries. To reduce the possibility of war and to maintain peace, an organism of mutual-trust must be established. It will be an important work in defense governance how to lower conflicts, enhance mutual-trust, and cooperate for common interest. After the various related acts have been enacted, the ROC government is working toward modernization. It is hoped that the government can be adapted to the traits of the comprehensive global security system to secure its own national interest and achieve its own national goals.

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THE RELATIONSHIP BETWEEN INSTITUTIONAL PRESSURE AND THE BUSINESS RESPONSE STRATEGY: A CASE STUDY OF TAIWANESE FIRMS IN MAINLAND CHINA

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ABSTRACT

This study applies institutional theory to explore the sales network of Taiwanese Notebook PC firms in Mainland China. The purpose of this study is to find out the response strategy of marketing channel under institutional pressures. Adopting case study method, this research concludes several propositions based on theory and case description. After surveying case of Acer, this research found that firm's sales network tend to be isomorphic alliance as the regulative institution pressure is strong. As the regulative institution pressures become weaker, firm tends to follow the organizational practice, such as internalized sales network. As the regulative institution pressure become weaker but the cultural-cognitive institution pressure is relatively high, firm's sales network tends to be efficient alliance.
Keywords: institutional theory, institutional pressure, response strategy, Mainland China, Acer

INTRODUCTION

Since the 1980s, the amount of FDI by Taiwanese corporations has grown enormously. Among these outward investment countries, China represents the most popular host countries. As the Chinese domestic market has been opened, the investing activities of Taiwanese firms have been transferred gradually from building production base to exploring local market. How to manage business in China has been the concern focus of practitioners. However, Chinese market possesses the environment uncertain traits of emerging market. The transaction cost and relevant resources in China were then different from the West. Recently, the number of scholars applying institutional theory to analyze the strategies of emerging market was increasing gradually.

Different schools have different interpretation about the formation, evolution, operation, and outcomes of organizational alliances and networks. From the view of theory development, there are two streams of thought: economics-based views of alliances and the corporate strategy perspective. Most previous studies based on transaction-cost theory have tended to understate the significance of contextual factors in the choice of entry mode. On the other hand, many of these contributions from corporate strategy perspective lack a cohesive theoretical perspective. The institutional perspective offers the hope of potential integration of the economic and strategic perspectives because of the multiplicity and complexity of alliances and networks. After that, there is a growing number of studies began to apply institutional theory to analyze international business management. Besides, marketing channel can be viewed as relationship network, therefore the study treated marketing channel as an alliance network.

THEORETICAL BACKGROUND

Institutional Theory

Early versions of institutional theory placed particular emphasis on the taken-for-granted character of institutional rules, myths, and beliefs as shared social reality and on the processes by which organizations tend to become instilled with value and social meaning [3]. In recent years, the institutional school has evolved as a major theoretical approach describing and explaining organizational structures and actions [2]. Institutional theorists argue that the driving force behind organizational action is a desire to achieve a fit with the organization's normative context. Scott [6] concluded three pillars of institutions: regulative, normative, and cultural-cognitive. The regulative institution constrains and regularizes behavior. The normative institution introduces a prescriptive, evaluative, and obligatory dimension into social life. The cultural-cognitive institutions share conceptions that constitute the nature of social reality and the frames through which meaning is made. Institutional theorists have explained the homogeneity of organizational forms and actions as residing in the isomorphic tendency of organizations seeking conformity to institutional pressures to increase legitimacy, reduce uncertainty, and increase standardization.

The Institutional Pressure and Responding Strategies

There are several pressures for conformity to institutional norms. Coercive pressures arise from broad-based societal expectations as well as from organization-organization interdependencies, normative pressures stem from professionalization, while mimetic pressures are experienced as a function of efforts to reduce uncertainty [2]. Each pressure derived respectively from the three pillars of institution that is regulative, normative, and cultural-cognitive [6].

Oliver [3] argued that the institutional framework can readily accommodate a variety of strategic responses to the institutional environment when the degree of choice and activeness that organizations exhibit in response to institutional constraints and expectations is not assumed to be invariant across all institutional conditions. She delineated five general strategies available to individual organizations confronting institutional pressures: acquiescence, compromise, avoidance, defiance, and manipulation.

RESEARCH METHODOLOGY

Research Procedure

The purposes of this study are threefold: (1) to describe changes of sales network, (2) to determine the influence of institutions on the sales network, and (3) to reveal subsequent strategic responses of firms. A case study research method is found to be best suited to an in-depth understanding of the interactive relationship between institutions and the sales network evolution.

In accordance with the accepted steps of a case study, the theoretical aspects of the relevant research are reviewed first and constitute the preliminary research direction. This is followed by case study interviews with the gathering of secondary material for the clarification of the questions probed by this study; and, finally, in accordance with the discoveries of theoretical deduction and the case study interviews, the research propositions are suggested.

Cases Selection

There are about 10 Taiwanese NB PC firms investing in China. Among these firms, only Acer and Asus developed their China marketing channels aggressively. However, Acer gets success comparing to

other firms and can be the best represent of NB PC firms. Therefore, this study chose Acer as research case.

Data Collection

The collection of the case study data employed both primary and secondary data. The primary data principally used employee interviews with the companies and employee. Prior to the interviews, the interviewed companies were phoned and, if possible, the upper-level management of the company was asked to agree to being interviewed. Secondary information included magazine reports and the company's own public announcements, annual reports and corporate profiles. Through the acquisition of material from different channels, the impact of the subjective opinion of the interviewee was reduced and the multi-faceted authenticity of the case was allowed to emerge.

THE INSTITUTIONAL ENVIRONMENT OF MAINLAND CHINA

There are three pillars of institutions. However, this research found that there's little influence of normative institution on Acer's operations. We will describe the contents of regulative and cultural-cognitive institutions as follow.

Regulative Institution

There are three major regulations that bring pressures to firms' operations:

- **Domestic Sales Rights**: In the beginning stage of China reform, government set up the constraints of domestic sales percentage to protect domestic industries. The foreign investors need to report the sales percentages of foreign market and China local markets before setting up the enterprise. The report need to submitting to county government of the enterprise location and its upper government levels. The procedures to get domestic sales rights are very complex and also take long time.
- **Government Procurement Law**: China always aims to foster their domestic companies and industries. In year 2003, they have published the "Government Procurement Law" to regulate government procurements should always consider buying domestic goods, engineering jobs and services in higher priority so that they can foster local companies. As to Taiwanese companies, besides the good quality and service of products Taiwanese companies also need to establish good relationship with China governments and cooperate with China companies to get the bids of China governments.
- **Value Added Tax**: China government has regulated the scopes of Value Added Tax (VAT) which include consign the goods to other parties for selling, as well as sell the consigned goods. If Taiwanese companies ask agents to sell merchandises in China, it needs to be levied 17% VAT according to the laws. Even though VAT can transfer to agents then agents transfer to consumers, some China agents do not obey the laws and not pay the taxes. Taiwanese companies need to oversee the agents to pay the VAT to avoid potential lawsuits which will increase the extra costs of Taiwanese companies.

Cultural-Cognitive Institution

Finally, there are two major pressures belong to cultural-cognitive institution:

- **Guanxi**: For doing business in China, it is very important to have personal relationship or marital relatives' relationship with relevant organizations.
- **Solve conflicts by informal mechanism**: Most business strives in China are reconciled by related parties' private discussions and not through courts of law. The law structure in China normally

allow associations, family organizations and other non-government organizations to solve the contract strives and decide when can terminate cooperation agreements

CASE DESCRIPTION

Beijing Acer Computer Ltd. is responsible for marketing and after services of Acer products in China. It also set up service and repair centers in Beijing, Shanghai, Ghangzhou, Chengdu, Wuhan, Shenyang and Xi'an. Acer's marketing structures can divide into five stages. They are: nationwide agents, own branch offices, province level agents, exclusively nationwide agents system, and multiple distribution systems.

Stage I: Nationwide Agents
In year 1993 Acer notebook PC first time entered China market. Since no domestic sales rights at that time, Acer cooperated with four nationwide agents systems. These nationwide agents can reduce risks, and responsible for customs clearance, accounts receivables and distribution of goods.

Stage II: Own Branch Offices
After getting domestic sales rights of domestic more than one thousand distributors, Acer has started to consider stopping nationwide agents system. For effectively managing distributors in all areas, Acer began to set up their own branch offices. In year 2002, Acer had set up seven sales organizations. In year 2003, there are more than ten branch offices being set up in Jinan and Nanjing. In Nov. 2003, Acer cancelled the four nationwide agents' products selling rights and replaced by Acer own branch offices to manage province level agents and city level distributors. This is Acer's flat marketing structure policy.

Stage III: Province Level Agents
However, the abolishment of nationwide agents system did not succeed as Acer expected. In year 2004 Acer branch offices had exposed various problems such as management of accounts receivables, usage of credit lines and management of bidding price etc. The most disappointing phenomenon is that the sales revenues had not increased by the increase of branch offices. In China, the situation of distributors not paying value-added tax often happened. Plus the geographies differences of China, the costs to manage more than one thousand distributors by branch offices are very high. To effectively managing distributors in all areas, Acer had decided to adopt geography agents system. In Sept. 2004, Acer proceeded the second wave channel reform. From the original flat channel system changed to province level agents system.

Stage IV: Exclusively Nationwide Agents System (New Distribution Model)
Because of the "new distribution model" in Europe very successful, Acer has 40% growth rate in first quarter of year 2003. In year 2005, Gianfranco Lanci has become the Acer Global G.M. who announced that China will also adopt the "new distribution model" and restore nationwide agents system. The "new distribution model" means any retail stores can utilize the B2B e-commerce system to directly order from Acer branch offices according to consumers' needs. By this system, the retails stores do not need to order from geography agents so that they can be without the exploitation from the geography agents.

Stage V: Multiple Distribution Systems
In June 2005 Acer formally announced the restoration of nationwide agents system and adjusted the channel structure to "four big operations centers, two nationwide agents". The first nationwide agent

Acer chose is Ingram Micro Inc. who ranks as number three in China IT channel companies. In Sept. 2005 Acer announced that Digital China has become their second nationwide agent. The 103 geography agents who used to supply directly by Acer now have been managed by Ingram Micro Inc. and Digital China these two nationwide agents. Since then, Acer has been concentrating on the promotion of Acer brand, and the sales and logistics jobs have been handled by Ingram Micro Inc. and Digital China. Besides, Synnex and UNIS are also responsible for Acer products distribution in 3C retails stores and geography markets. At that time, Acer's sales network has been changed from original Ingram Micro Inc. as exclusive nationwide agent to the multiple channels system which consists of two nationwide agents and a few geographies distributors.

PROPOSITIONS SUMMARY

From theory point of view we can understand that the choice of organizational structure is affected by external environment and internal organizational convention [1] [5]. From the case study we found that Acer had adjusted their sales network when facing the external pressure of institutional environment. When these institutional pressures disappeared, the sales network of both companies came back to the organization conventional practice, such as in Acer's second stage to set up its own branch offices and in fourth stage Acer's new distribution model. By summarizing the above theories and analyzing the cases studies, this research deduct that the sales network construction will be influenced by local institutional environment. When institutional pressures are very large, companies will adjust organizational structure to comply with institutional requirements. When institutional pressures reduced, companies will go back to organizational practices. So this research has summarized Proposition 1 as following:

> ***Proposition 1:*** *When institutional pressures are large, firms will adjust their sales network to comply with institutional requirements; on the contrary, when institutional pressures are small, companies will tend to design their sales network according to their organizational practices.*

Institutional theory and transaction cost theory have different considering factors regarding organizational structure choice. Transaction cost theory consider "efficiency" is the major deciding factor and institutional theory consider "legitimacy" is major deciding factor; institutional theory scholars suggest that organizations should obey other organizations in environment to increase the legitimacy even though these activities lacking efficiency. Roberts and Greenwood [4] feel that organizations will first consider efficiency as basis and evaluate current design then search for possible substitute proposals and finally come out the most efficient design. But after considering institutional pressures, during the decision-making process organizations will keep reviewing whether their choices can comply with environment requirements to adjust their decisions. When facing the conflict between efficiency and legitimacy, organizations tend to consider legitimacy first.

Acer cooperated with agents when they just entered the China market. Even though the transaction costs are very high, Acer must adopt the nationwide agents institutional since the institutional pressures from lack of domestic sales rights. This phenomenon also happened in the third stage of Acer. Although in Stage III, there was lower regulative institutional pressures but cultural-cognitive institutional pressures was still high. To established guanxi network, Acer cooperated with agents again. That is what we called as "isomorphic alliance sales network model" in this research. When institutional pressures become lower, in case of Acer's Stage II, firm will tend to follow organizational practices to build up its own sales network (see Proposition 1). However, Acer ignored the influences of

cultural-cognitive institution. That's why the period of Stage II is the shortest one. When facing lower regulative institutional pressures but high cultural-cognitive institutional pressures, Acer should cope with the cultural-cognitive institutional pressures. Therefore, Acer adopted alliance network and transferred the pressures to its partners. Because the purpose of building nationwide agents system was to pursue efficiency, we call the alliance in Stage IV and V as efficient alliance sales network model.

By combining the viewpoints from theory and findings from case study, this research found that firms will adopt various sales network models according to different institutional pressures. Based on this logic, this research deducts Propositions 2 and 3 as following:

Proposition 2: When facing strong regulative institutional pressures, firms tend to pursue legitimacy and adopt isomorphic alliance sales network model.

Proposition 3: When facing strong cultural-cognitive institutional pressures, firms tend to pursue efficiency and adopt efficient alliance sales network model.

CONCLUSIONS

China domestic markets become larger and the competition become tougher day by day. Moreover, the life cycle of notebook PC is short and product homogeneity is very high. To avoid the price war, firms must perform well on channels management so that their products can get the market shares quickly. This research considers marketing channel as networking relationship and study the choices from internalization to externalization. We found that firms will adopt various sales network models according to different institutional pressures. Based on our research findings, we suggest firms should clarify their institutional environment firstly and then adopt adequate alliance sales networks to cope with the uncertainty of environment.

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THE IMPACT OF MARKET PERFORMANCE AND USAGE EXPERIENCE ON BRAND EXTENSION

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ABSTRACT

The purpose of this study is to examine the effects of consumer usage experience with the extension product and its market performance information on parent brand, moderating by the extension similarity. Three experiments were implemented to test the hypothses. The results demonstrate that the positive usage experience and market performance informantion on far extension can improve the negative reciprocal effects on parent brand. On the other hand, the negative usage experience and market performance information will jeopardize the percive fit of close extension and dilute the parent brand evaluation. Besides, for far extension, when the market performance has negative information, the positive usage experience will reduce the negative reciprocal effects. However, for close extension, when consumer has negative usage experience, the positive market performance information will not improve the negative reciprocal effects.

Key word：brand extension reciprocal effect, brand dilution effects, usage experience, market performance.

INTRODUCTION

Brand extension has been recognized by the academicians and practitioners as one of the effective methods to build brand equity. It means that the brand equity of parent brand can be strengthened via successful new product introduction. However, its brand equity may be diluted by the resulting negative information if the new product introduction failed. Furthermore, the dilution effects may still occur even the new product introduction is successful due to different product category image or the inconsistent extension. Therefore, researchers are just beginning to examine the so called reciprocal effects of brand extension, positive or negative impact on the parent brand (Chen and Chen 2000；Gurhan-Canli Maheswaran 1998；John, Loken and Joiner 1998；Swaminathan, Fox and Reddy 2001).

Based on literature review, most of the research were focusing on the initial perception about the new product to evaluate the performance incongruent extension. Some other studies manipulated the extension to be the unsuccessful situation (market performance) to examine the reciprocal effects. We think that this is still different from the real situation in the market. Interestingly, the usage experience was utilized to examine the extension effect (Sheinin, 2000). Therefore, we try to incorperate the usage experience with the market performance to examine the reciprocal effects. Thus, the purpose of this study is to examine the effects of consumer usage experience with the extension product and its market performance on parent brand, moderating by the extension similarity. The specific research questions are summarized as below:

1. When doing the far extension, will the positive usage experience and market performance improve the original dilution effects?

2. When doing the close extension, will the negative usage experience and market performance dilute the original positive reciprocal effects?
3. How are the different interaction effects between usage experience and market performance on parent brand? When consumer has negative usage experience, will the positive market performance information improve the negative reciprocal effects? When the market performance has negative information, will the usage experience (product improvement) decrease the negative reciprocal effects?

LITERATURE REVIEW and HYPOTHESES

One of the most robust findings in past research is the role of the semantic relationship between the parent brand and extension category in determining brand extension evaluations (Aaker and Keller 1990; Broniarczyk and Alba 1994; Park, Milberg, and Lawson 1991). In particular, research has shown that consumers provide more favorable evaluations when the extension category is perceived to similar to the parent brand than when the extension category is perceived to be dissimilar (Boush and Loken 1991; Keller and Aaker 1992; Loken and John 1993). Therefore, extension similarity is also the most popular variable being used to examine the reciprocal effects on the parent brand, particularly on the dilution effects. Prior research indicated that the performance of incongruent far extension was not as good as the close extension, and would dilute the parent brand, even did not mention if it was successful or unsuccessful. However, those research normally based on consumer perception only to judge the extension performance. Sheinin(2000) firstly explore the effects of experience with brand extension on parent brand knowledge, and found differences in beliefs about unfamiliar parent brands between positive and negative experience but no differences in beliefs about familiar parent brands.

Therefore, we argue that consumer might change their perception on beliefs for far extension if they can have positive usage experience. On the other hand, the informance of positive market performance might enhance the willingness to try for the new users and then decrease their negative intention toward the far extension. We expect the dilution effect might be decreased. On the other hand, Many brand extension researchers cite an affect transfer process to describe extension evaluations. According to this model, when the extension category is similar to the parent brand category, perceived fit is high and extension attitudes are likely to be based on attitudes toward the parent brand. For close extensions, the extension category is similar to parent brand, its reciprocal effects should be smaller. However, if the direct negative experience come out, comsumer might change the perceived fit to using bad experience to judge the extension and result in negative evaluation. We expect this situation will happen to the negative market performance for close extension. As a result, the hypotheses were shown as follow:

H1a：When doing the far extension, the reciprocal effects on parent brand for extension with positive usage experience will be better than that without usage experience.

H1b：When doing the far extension, the reciprocal effects on parent brand for extension with positive market performance information will be better than that without positive market performance information.

H2a：When doing the close extension, the reciprocal effects on parent brand for extension with negative usage experience will be lower than that without usage experience.

H2b：When doing the close extension, the reciprocal effects on parent brand for extension with negative market performance information will be lower than that without market performance information.

This research was aimed to investigate that under the context of positive and negative using experience, whether positive and negative market performance will result in positive reciprocal effect or negative dilute effect. In other words, when consumer had negative usage experience (dilute effect probably existed) on close extension (initial perception was positive), whether positive market performance information would improve the dilute effect of consumers on parent brand. Nevertheless, when consumers had the message of negative market performance toward far extension, whether positive using experience would improve negative reciprocal effect. As a result, the hypotheses are shown as below:

H3：There will have the different interaction effects between usage experience and market performance on the reciprocal effects of parent brand.

H3a：For close extension, when consumer has negative usage experience, the positive market performance information will improve the negative reciprocal effects.

H3b：For far extension, when the market performance has negative information, the positive usage experience will reduce the negative reciprocal effects.

RESEARCH DESIGN

Experimental Design

Three experiments were conducted. At the first experiment, the initial perception from customers on extension performance for close and far extension was conducted and used to be the following compared control group. The second experiment took 2x2 between subjects design, from two different conditions (positive or negative market performance) and product extensions (close or far) discussing the reciprocal effects to parent brand. The third experiment took 2x2x2 between subjects design, including market performance (positive or negative), customers usage experience (positive or negative) and different product extensions (close or far). The customers positive and negative usage experience was controlled by physical products. Market performance was manipulated in word description. Starbucks Coffee was chosen as the parent brand. Besides, far or close products extension category similarity was judged by the pretest.

Procedure and Dependent Measures

Subjects were recruited via convenient sampling from undergraduate students class to participate in the experiments. Five hundred twenty five effective samples were collected after deleting thirty eight ineffective samples i.e. incomplete answering, or incorrect comprehensive checks. All subjects were randomly assigned to conditions and completed a questionnaire booklet. The researcher was explaining

the purpose that is the market test of the new product. In the beginning of the questionnaire, the basic information about the new product (milk tea or puding) introduction of Starbucks was shown in the first part. Each subject needs to read the description of manipulation.Then, subjects will tried the new product and first answered some comprehensive checks regarding the market performance information and usage experience manipulation check. Then subjects provided the ratings toward parent brand Starbuck coffee after the new product introduction. The last part was the demographic information.

Dependant measures including perceived quality, belief, attitude, and purchase intent. All items were using seven-point scales. Perceived quality (high/low quality) was measured on a single-item scale. Belief was measured as an average of three items toward its brand proposition (agree/disagree, high/low reliability, believable/unbelievable, α= .9546). Attitude was an average of three items (good/bad, very appealing/unappealing, good/bad to eatα= .8965).

RESULTS AND ANALYSIS

In study 1, we examined the initial perception difference for the negative reciprocal effect between close and far extension. The results indicated that the reciprocal effect for far extension is higher than that of the close extension (perception quality =3.69 VS 5.28 ($P<0.05$)、belief 3.47VS 4.95 ($P<0.05$)、attitute 3.95 VS 4.97 ($P<0.05$)、purchase intent 2.58 VS 3.85 ($P<0.05$). This is also consistent with previous research. We used this result as a control group for the next two studies.

In H1, we try to examine if the positive usage experience and market performance informantion on far extension can improve the negative reciprocal effects on parent brand. The ANOVA revealed significant main effects for experimental group and control group, The contrast test vs. control group on all dependent variables (quality, belief, attitute and purchase intent) were showing significant difference ($P<.001$). Details please see Table 1. This indicated that both of two stimuli enhanced the perception on parent brand and redcued the possible dilution effects. Thus H1 was supported..

Table 1
The reciprocal effect of positive usage experience and market performance on parent brand under the far extension

Dependent variables	Positive Usage experience	Positive market performance	Control group	F-value	P-value
	n=73	n=34	n=36		
Quality	5.00	4.88	3.69	15.815	.000
Belief	4.28	4.39	3.47	8.070	.000
Attitude	4.91	4.41	3.95	9.984	.000
Purchase intent	3.55	3.24	2.58	7.239	.001

In H2, we changed to test if the negative usage experience and market performance information will jeopardize the percive fit of close extension and dilute the parent brand evaluation. Consitent with our

intention, the parent brand due to its close extension with.negative usage experience or negative market performance was seen by subjects less faverable than the control group. The ANOVA demonstrated that all dependent variables on the experiment groups were significant lower than the control group (P<.01), which means the dilution happens for the close extension due to the negative usage experience or negative market performance information. Thus H2 was surpported.

Table 2
The reciprocal effect of negative usage experience and market performance on parent brand under the close extension

Dependent variables	Negative Usage experience	Negative market performance	Control group	F-value	P-value
	n=79	n=40	n=40		
Quality	4.63	4.68	5.28	5.738	.004
Belief	4.14	4.19	4.95	8.674	.000
Attitude	4.47	4.49	4.97	4.800	.009
Purchase intent	3.09	3.28	3.85	8.568	.000

We have seen the positive usage experience had positive effect for the far extension to reduce the possibility of dilution on parent brand and the negative usage experience had negative effect for close extension to dilute parent brand. The positive and negative market performance information also had the same results. We speculate that how can we use the positive market performace to attract those consumer who has negative usage experience. It means that for close extension, when consumer has negative usage experience, will the positive market performance information improve the negative reciprocal effects? As we expected that the positive market performace failed to produce any significant effects on parent brand for all dependent variables. This revealed that the negative usage experience may have deep impact on subjects and is difficult to change its beliefs via the market performance information. Maybe unless consumer has a chance to experience positive usage. Thus, H3a was not surpported.

Table 3
The reciprocal effect of the close extension on parent brand under the different market performance and usage experience

Dependent variables	Negative usage experience	Negative usage experience and positive market performance	F-value	P-value
	n=79	n=37		
Quality	4.63	4.95	.885	.369
Belief	4.13	4.33	.751	.388
Attitude	4.56	4.74	.725	.391
Purchase intent	3.09	3.51	.856	.357

As suggested in H3b, the results showed that for far extension, when the market performance has negative information, the positive usage experience will reduce the negative reciprocal effects. The ANOVA results showed that there had the significant main effects on perception quality (4.32 vs. 4.97, P<0.05)、belief (3.71 vs. 4.23, P<0.05)、attitute(4.33 vs. 4.96, P<0.05) and purchase intent (2.54 vs. 3.69 P<0.05). This indicated that consumer may more rely on their direct experience. Thus, H3b is surpported.

Table 4
The reciprocal effect of the far extension on parent brand under the different market performance and usage experience

Dependent variables	Negative market performance	Negative market performance and positive usage experience	F-value	P-value
	n=37	n=43		
Quality	4.32	4.97	5.650	.020
Belief	3.71	4.23	4.092	.047
Attitude	4.33	4.96	5.927	.017
Purchase intent	2.54	3.69	19.117	.000

CONCLUSIONS AND IMPLICATIONS

The purpose of this study is to examine the effects of consumer usage experience with the extension product and its market performance on parent brand, moderating by the extension similarity. The results demonstrate that the positive usage experience and market performance informantion on far extension can improve the negative reciprocal effects on parent brand. On the other hand, the negative usage experience and market performance information will jeopardize the percive fit of close extension and dilute the parent brand evaluation. Besides, for far extension, when the market performance has negative information, the positive usage experience will reduce the negative reciprocal effects. However, for close extension, when consumer has negative usage experience, the positive market performance information will not improve the negative reciprocal effects.

From theoretical point of view, this study provides a new role for usage experience and market performace information in the brand extension literature, particular in the reciprocal effects. Not just only induvidual effect for usage experience and market performace information being examined respectively, but also exploring its interaction effect, using positve effect to “rescue” the other negative effect. For managers, the trial promotion for the far extension is vital not only to enhance extended product launch, but also to minimize the dilution on parent brand. On the other hand, the continuous product improvement is also essential because the positive usage experience can rescue the bad performance in the market.

Reference upon request

SPIRITUALITY AS PART OF STRATEGIC PLANNING

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ABSTRACT

In noting the evolution and recent resurgence of spirituality in the workplace, the concept of spirituality as a business strategy is defined and examined; business strategy is defined. Questions and suggestions of how to incorporate spirituality into a business strategy and how to measure it are considered. Spirituality as a foundation of a positive and retentive workforce is shown through Southwest Airlines and KeySpan organizations. Actual work experiences gleaned from an interview with Kenny Moore, co-author of The CEO and the Monk (former priest and ombudsman at KeySpan) are interspersed. Additionally, Deming's 14 points are paralleled with Moore's ideas. Japanese culture is compared to American culture. Ethical concerns of spirituality in the workplace are considered.

KEYWORDS: SPIRITUALITY. STRATEGY. KENNY MOORE. EMPLOYEE PERFORMANCE.

INTRODUCTION

There is a growing concept in today's workplace that is about ten years old: spirituality. Yet fifteen hundred years ago, St. Benedict wrote a rule for his nuns and monks reminding them of the interrelatedness and interconnectedness of work to spirituality: "human labor is modeled on God's labor . . . activity that flows forth from the essence of one's being, as well as in beneficial care for others . . . 'co-creative' . . .fulfilling for ourselves" [18, p.3-4]. Some organizations are considering spirituality a necessity for success as ISO certification is. This paper will address spirituality as a workplace strategy, namely, as a positive contributor to employee performance that is subsequently beneficial to the organization. To investigate spirituality as a business strategy, resources are cited with quotes from an interview with Kenny Moore, former priest, Ombudsman at KeySpan and co-author of The CEO and The Monk. References to KeySpan and Southwest Airlines will offer spirituality examples.

SPIRITUALITY DEFINED

Explaining spirituality in general terms is like trying to describe a sunrise to someone who has never seen one: it is available for all, its affect is different for everyone, and although it can be defined, the essence is difficult to capture. You just have to be there. In a similar way, spirituality embraces everyone, is available for anyone and yet is different for everyone. For some, spirituality may mean faith, values, or a oneness with their surroundings. "Spirituality at work is not about religious beliefs. Rather, it is about people who perceive themselves as spirited beings, whose spirit needs energizing at work. It is about experiencing real purpose and meaning in their work beyond paychecks and task performance" [6, p.155]. Researchers have written at length about coming to a single, agreeable definition about workplace spirituality [2, p.367]. A 1997 study about spirituality in the workplace reported that nearly ninety respondents were in agreement of a definition for spirituality as "the basic desire to find ultimate meaning and purpose in one's life and to live an integrated life . . . the search for meaning, purpose, wholeness and integration is a constant, never-ending task" [12, p.xv]. This leads us to consider spirituality as intrinsic rather than a specific religion or a display of worship. We therefore refer our research of spirituality to value (intrinsic ideal), purpose (aim, determination) and meaning (hidden significance).

STRATEGIC PLANNING DEFINED

Defining strategic planning is straightforward in comparison to spirituality: "the set of decisions and actions that result in the formulation and implementation of plans designed to achieve a company's objectives" [16, p.3]. It is the task of the business manager to: formulate the company's mission; analyze the company's conditions; evaluate the external environment; review the company's options of internal resources vs. external environment; identify the options; develop and select long term, short term and annual strategies; implement these strategies and measure and evaluate the success. Internal resources involved in strategic planning include tasks, people, structures, technologies and reward systems; external environment involve competition, scarce resources, and government regulations. There are many activities and dimensions connected with strategic planning that are not mentioned in this abbreviated explanation. The main goal of strategy is for the manager to develop a plan to meet company objectives (bottom line) through the use of available internal resources within the existing external environment. It is within the context of our research that we relate a corporate strategy of spirituality as a positive support of employee performance and thereby contribution to the organization. "A growing movement across the country is promoting spiritual values in the workplace and pointing to many examples of increased productivity and profitability" [9, p.84].

SPIRITUALITY IN ORGANIZATIONS

In reviewing the tasks involved in strategic planning, there are several considerations making spirituality foreign and insignificant to a business organization: how could spirituality be included in business planning, why include this subject, and is spirituality measurable to the bottom line? These questions will be addressed.

WORKPLACE CLIMATE

In consideration of managers' tasks to implement strategies to meet the company's mission and bottom line, it is little wonder that there is so much stress in the workplace. Management must keep its shareholders happy; maintain and expand its customer base; acquire quality yet cost-savings materials from suppliers; struggle to outsell the competition. To meet these goals, management decisions over the last several years have included outsourcing to overseas suppliers at minimum costs; downsizing the workforce; merging of companies and imposing long working hours onto workers. In the midst of these occurrences, organizational scandals of CEO's with thickly lined pockets have abounded. Additionally, organizational decisions causing ethical dilemmas and lacking social responsibility have been commonplace. As a result, many workers have become disheartened, disconcerted and distrustful of their organizations. Such employee attitudes linked with high turnover and low morale, filter through the ranks and are reflected in the manner of conducting work tasks. Whether the employee interacts with internal or external customers, problems can occur which ultimately affect the company's bottom line. In choosing products and services, the trend for customers and stakeholders is to judge an organization by how it is ethically and socially responsible, how it takes care of its employees and whether or not good customer service is available. "Any good company knows that its only truly sustainable competitive advantage is its people. Goods and services can be copied, but people cannot be. So when you go through tough times, you need your workforce to be ready for battle. You want them fit, mentally engaged, and focused" [3, p.70].

REDISCOVERING SPIRITUALITY

The WORKPLACE CLIMATE section intimates the necessity to incorporate spirituality in the workplace. But there are obstacles. The subject of workplace spirituality is taboo; people sense that it is not polite to discuss value, purpose and meaning in the confines of the workplace. The idea of spirituality in the workplace brings a perceived threat: What will we do with it? How do we get it here? Kenny Moore says: "You don't bring spirituality into the workplace . . . you cannot bring something in if it is already there . . . Work, as it is, business, as it already is, is sacred. This is the place where people gather to live out their lives and their efforts, where they contribute themselves and their creativity. It is already sacred" [13]. This smacks against the years of leaving our spirituality at home and compartmentalizing our lives: it is okay to bring all of myself (values, self, purpose) to most places but not to others, especially my job. With this thought, workers cautiously protect themselves, stifle and guard words and actions, not comfortable to express their true selves. Figure 1 outlines the evolvement of the influence of religion (Protestant Ethic) in the workplace as well as a hint of spirituality (value, meaning, "work as sacred") from the Middle Ages to the 21st Century. It is within the last ten years that business journals and books have rediscovered and named spirituality as important to organizations. To reiterate, it is a spirituality of values, meaning and purpose, sacredness "already there," rather than a display of religiosity or scheduled Bible study.

EVOLUTION OF THE INFLUENCE OF SPIRITUALITY IN WORK

Middle Ages	Roman Catholic Influence: "monastic life of prayer better than labor";
16th Century Protestant Reformation Protestant Work Ethic	Martin Luther: "salvation by faith alone, not by works"; John Calvin: "man's spiritual future is linked to earthly labors; man has a calling; sacred values connected to all types of work".
17th Century Protestant vs. Catholics in England; Protestants call themselves "Separatists"; Sail to "The New World" as "Puritans"	Puritans: "be honest, just and work hard to honor God and fulfill your calling in life"; this fulfills life with meaning and purpose; what we know as the "Protestant Work Ethic";
18th Century Protestant Ethic (Puritan)	Continues to contribute to development of the "New World";
19th Century American Civil War	Secularism, industrialism, affect religious attitudes; work becoming separated from religious values; money fulfills life;
19th into the 20th Century Secular Humanism	Church separated from the state; questioning of moral, ethical, and Biblical values; rejection of God, emphasis on self and rewards (money);
20th into the 21st Century	Work attached to secular values; no longer seen as "sacred";

FIGURE 1 (Excerpts from [14] "Vision: A Journal for a New World", Orchard)

BACK TO THE FUTURE

During the interview, Kenny Moore explained the energies within an organization, each having its own percentage of contribution from the greatest to the least: physical energy (goods and services); mental energy (management decisions); emotional energy (relationships); spiritual energy (meaning and purpose). Supporting this idea, Richard Barrett, in his article "The Value of Values" stresses similar employee energies: "What every employee wants, no matter where they are in the hierarchy is to find as much personal fulfillment as they can through their work. Everyone in the organization is seeking to satisfy his or her physical, emotional, mental and spiritual needs . . . Our spiritual needs are met when we find meaning in our work, when we have the opportunity to make a difference and we feel we can be of service" [1]. Both Moore and Barrett encourage spirituality in the workplace and turn us back to the value, meaning and purpose of the Puritans of the past, the definition for spirituality we referenced earlier. How do we encourage these goals in the workplace?

STRATEGIC SPIRITUALITY AT KEYSPAN

KeySpan Corporation (a 100+ year old utility of NY, formerly known as Brooklyn Union Gas Company), like any business, must strategically plan goals to remain successful. Bob Catell, CEO of KeySpan, realized the importance of developing and encouraging employees who contribute within daily tasks that ultimately enhance the bottom line. These are excerpts of a quote from Elaine Weinstein, senior VP of Human Resources at KeySpan: "people historically come [to KeySpan] for lifetime careers . . .[KeySpan exudes] . . .emotional intelligence, an intuitive social awareness, a valuing of people, a commitment to the community . . . there is a tremendous flexibility built into the system that is focused solely on meeting employee's needs . . .it's about taking care of the employees and making sure they are there for their families, for themselves. . . what you get then is this enormously committed employee who is very grateful. It's not about guilt; it's how you build loyalty in a company" [3, p.69]. "You can force people into work; you could make them comply . . . the key is to invite them" [13]. Peter Senge stressed this same idea: " . . . there is a world of difference between compliance and commitment. The committed person brings an energy, passion, and excitement that cannot be generated if you are only compliant . . . the committed person doesn't play by the 'rules of the game.' He is responsible for the game" [17, p.221].

SPIRITUALITY AT KEYSPAN & SOUTHWEST AIRLINES

During the interview and in the book, The CEO and The Monk, Kenny advised: "Spirituality at work isn't about hosting prayer groups or Bible study sessions in the workplace. I don't think the business world is ready for that, and I'm not sure it should be" [3, p.234]. Examples taken from Kenny's interview, KeySpan and Southwest Airlines are used to explore workplace spirituality. Kenny explained his role as ombudsman at KeySpan: an "improv comedian, a mid-wife," catching ideas and using "timing" to dictate the appropriate time and place to bring out the spiritual [12]. Whether Kenny is attending a management meeting or having a one on one with an employee, these are his spiritual opportunities. Spirituality at KeySpan is a manager sharing a meal with an employee ("Break Bread Dinners"), phoning an employee at home with a "great job" message or paying a hospital visit to an employee. There are work groups and

employee sessions. KeySpan allows employees to display their artist endeavors with respect to their co-workers.

In a research article dedicated to Southwest Airlines' (SWA) spirit, the question is posed "whether spirituality in the workplace can be used only to benefit employees or if it can be developed also to the advantage of organizations" [10]. To answer this question, the researchers attribute SWA's history of profit, market share, and frequent "Best Company to Work For" awards to a spirituality influencing their employee base and vice versa: "SWA is widely viewed as having a very strong set of values which shape its corporate culture . . . many of these values are manifestations of spirituality" [10]. Milliman et al. cite workplace spirituality as community, teamwork, service to others, having a purpose, employee empowerment, and the encouragement of humor: all spiritual qualities exemplified by SWA. "The culture at SWA reflects the view of having . . . people who take their jobs seriously, but not necessarily themselves . . . the philosophy is that happy and relaxed employees are also more productive" [10]. Employee empowerment and humor at SWA are explained to be strong contributors to SWA's success. Employees are hired for their humor and positive attitudes, not their technical skills. They are encouraged to wear costumes on the job and are empowered to break from company procedure if the decision benefits someone.

As with SWA and KeySpan, other companies have encouraged spirituality with strategically planned events (see Figure 2): vision quests (groups sent to a remote locale to hash out ideas); pass the rock sessions (the one holding a rock in a meeting has the floor to speak, others must listen); workshops, teambuilding and creative imagery: anything that enhances the present moment. All these activities encourage spirituality, connect and encourage employee value, purpose and meaning in the workplace. "We [KeySpan] need to provide the support for our [employees] whether that resource is training, venting, stress release, or whatever. If we're going through a period where there's going to be more stress and strain, any opportunity for people to develop a better comfort level, to feel free to express themselves, or to find avenues that help them bond together, that's critically important" [3, p.70].

FAMILIAR COMPANIES

- Aetna; Cirrus – meditation;
- Hewlett Packard – personal development;
- Tom's of Maine – connect employees;
- IBM – eastern philosophy to address concerns;
- XEROX – vision quests;
- Ford Corp. – Army chaplains hired;
- Taco Bell/Pizza Hut – traveling chaplains;
- Panera Bread – Operation Doughnation;

FIGURE 2

SUGGESTIONS OF SPIRITUAL STRATEGIES

Each company as a living organism has its own culture, budget and history. Strategies that work well for KeySpan and SWA may not be compatible with other organizations. Perhaps some spiritual strategies can be done in small steps: suggestion box for anonymous comments; availability of a non-threatening person to listen to employees' work or personal concerns; workshops for listening skills; sending of greeting cards (Kenny Moore has sent his co-workers Valentine's cards); sharing lunch with people of the same or other departments; hi-lighting an employee through a newsletter or bulletin board (their job description with some personal background they wish to share).

MEASUREMENT STRATEGIES

"If my contributions do not have a positive impact to the bottom line here, I would not be included [in management discussions] and rightly so" [13]. One of the important aspects of any business strategy is to measure and analyze the outcome of the plan: Was it successful? Does it need improvement? Likewise, with the suggestion to spend time and money to enhance spirituality in the workplace, it is beneficial that the organization measure the results. Figure 3 notes the business tools used in strategic planning over the years with an added suggestion to measure spiritual strategy.

MEASUREMENT TOOLS

1900's – 1960's; Mechanistic; Wealth for owners and shareholders	Financial sheets;
1960's – 1980's; Humanistic; Wealth, dignity for the above & employees	"100 Best Companies to Work For"
1980's – 1990's; Holistic; Wealth, accountability for the above;	Balanced Scorecard; Triple Bottom Line; Social Resp. Index
2000's – Just emerging; Service, fulfillment;	Balanced *Needs* Scorecard

(Excerpts from [10] "A Spiritual View of the Bottom Line" Miller)

FIGURE 3

SCORECARDS

"You can only improve that which you can measure" (a total quality adage). In all businesses, numbers are used to measure the financial climate and direction. The Balanced Scorecard is a popular tool used by most businesses to link measurements to

strategy. "The scorecard allows managers to evaluate the company from four perspectives: financial performance, customer knowledge, internal business processes and learning and growth" [15, p.194]. Robert Kaplan and David Norton developed this framework to illustrate that these four perspectives are connected to cause and effect relationships that lead to a successful financial strategy (improve, measure, improve, measure, etc.). In attempting to measure the spiritual, a non-financial, Richard Barrett has suggested two additional perspectives to measure: "corporate culture" and "society and community contribution" [1]. Barrett calls this a "Balanced *Needs* Scorecard." Barrett can be likened to an itinerant corporate preacher who globally conducts workshops about what he believes a recipe to business success: "People and companies do well, financially, and otherwise, to the degree that their interests match their values. To create that alignment you have to see it . . . have to find a way to measure that alignment and [have a] vision for improving it" [5]. Barrett is head of a consulting group whose mission is to "promote a model for business that allow people in their daily work to remain true to their deepest beliefs" [5]. The Balanced Needs Scorecard quantifies values of employees, their organization as they see it and the values of the employees' ideal organization (as they wish it to be). Barrett uses Maslow's hierarchy to plot and graph the final results: a visual of intrinsic values. The final results rate the values against social contributions, client and supplier relationships, corporate fitness, corporate survival, culture and evolution. Figure 4 is based on Richard Barrett's concepts:

VALUES BASED LEADERSHIP

FIGURE 4

REAPING SPIRITUAL BENEFITS

What happens when spirituality is part of workplace strategy? If nurturing of spirituality is done consistently and sincerely, an organization will have a better focus on ethics and social responsibility. The company will have ways to acknowledge the employee as person, as contributor, as team member. The employee, who spends conservatively 40 hours a week out of his /her life multiplied by years, is better able to participate on the job with a personal focus of finding meaning, purpose and value in assigned tasks. The journal articles researched and referenced for this paper (such as [9] and [11]) have reported that when spirituality is fostered in the workplace there is effective communication, a lower rate of employee turnover, improved morale and increased productivity. Marques quotes Dr. William Guillory: "First, profitability is a result of excellence in business function; and second, that a team of self-motivated, aligned and high-performing individuals is the best source of sustainability and excellence" [9, p.84]. An atmosphere that allows for employee growth and development creates a mindset that contributes positively to good customer service and a quality manner of handling tasks.

EFFECT OF SPIRITUALITY ON EMPLOYEE RETENTION

With the thought of employee performance benefiting the organization, we further cite: "Spiritual tools and practices have been proven to boost morale and retention, while cutting stress and absenteeism – nurturing a more energized, engaged and productive workforce" [7]. In addition to acknowledging the benefits of a productive workforce because of spirituality, it is important to see the benefits of a retentive workforce. "Turnover and replacement costs vary . . . replacing a worker who makes $48,000 a year could cost a company up to $40,000 in lost productivity, having to place recruitment ads, interview new candidates, train new employees and pay overtime to other employees who now have to pick up the slack . . . if you're a good businessperson, you want to create an environment where people don't leave" [8].

JAPANESE SPIRITUALITY AND QUALITY IN BUSINESS

A brief look about how Japanese spirituality (Zen, in particular) has influenced the Eastern workplace will shed light on the value of spirituality in the workplace.
In our focus on the Japanese culture, we consider a spirituality that is tied to their daily living and carried into the workplace for the most part. Figure 5 displays a side-by-side comparison of Japanese Zen culture to American culture. It is through the Japanese culture that Americans have gained insight into quality and business advancements (empowerment, poka-yoke and kaizen). In realizing the need for business advancement, the Japanese invited W. Edwards Deming to introduce quality methods that ultimately improved their market share. Deming's work with the Japanese and his introduction of the "14 points" won him the highest honor Japan could bestow. After the Japanese improved their processes and surpassed the West in business, Americans realized too late a need for quality improvement in the USA. Japanese culture and its close ties with Zen spirituality cultivated the ground for Deming and the quality improvements that many Japanese applied and still apply to their businesses.
Deming's 14 Points, his spirituality for quality, are paralleled with Kenny Moore's ideas of spirituality in the workplace in Figures 6 and 7. Viewing the parallel of Kenny's and

Deming's spiritual points show proximity of value centered goals to enhance the goods and services of the organizations, ideal to incorporate into a business strategy.

JAPANESE ZEN//AMERICAN CULTURE

㊢ Meditation;	$ Action;
㊢ Enlightenment;	$ "Show me the money";
㊢ Spirituality;	$ Worldliness;
㊢ Artists, poets, teachers;	$ Men of action;
㊢ Strive;	$ Defeat once;
㊢ Fluid;	$ Hard and fast;
㊢ Watch and absorb;	$ Imitate;
㊢ Non-resistance;	$ Over-apply power;

FIGURE 5

PARALLELS

DEMING'S SPIRITUALITY	KENNY'S SPIRITUALITY
• Consistent Purpose;	• Vision;
• Everybody Wins;	• Build Community;
• Design Quality In;	• Legacy;
• Buy from a Single Supplier;	• Commitment;
• Continuous Improvement;	• Purpose;
• Training for Skills;	• Acknowledge talents;
• Institute Leadership;	• Be authentic;

FIGURE 6

PARALLELS

DEMING'S SPIRITUALITY	KENNY'S SPIRITUALITY
• Drive out fear; cooperate;	• Repair trust;
• Break down barriers;	• Try to heal;
• Eliminate slogans;	• Take a risk;
• Eliminate numerical quotas;	• Make the impossible happen;
• Put joy in work;	• Have fun;
• Continuing education;	• Acknowledge talents;
• Accomplish transformation;	• Make an impact;
(Deming's 14 Points)	(Ideas from "Everything I Know About Business I Learned in the Monastery" by Kenny Moore)

FIGURE 7

ETHICAL CONCERNS

A discussion about spirituality in the workplace may seem harmless, but there are ethical considerations. While the purpose of spirituality is to influence employee value, meaning, and purpose, some workers may take offense. Workshops, teambuilding exercises and other programs need to be chosen with a diverse worker group in mind. It is best for an organization to center spirituality on generalities and avoid any specific tradition (i.e., Christian, Zen, and Judaism). " . . . Most companies are careful to stick to a cross-denominational, hybrid message that's often referred to as secular spirituality. It focuses on the pluralistic, moral messages common to all the great religions, such as plugging into something larger than yourself, respecting the interconnectedness of all actions and things, and practicing the Golden Rule" [4]. The influx of foreigners into US workplaces have brought people who wish to pray at a certain time of the day; workers who may wish to gather and read from a sacred text; workers who may wish to display a symbol of their faith in their work area. All this must be considered in light of the organization's policies and with respect to surrounding co-workers. Keeping spirituality in balance without the intent to harass or impose values and ideals contrary to individual workers must be foremost. "Generally employers are compelled to make 'reasonable accommodations' to employees with religious needs, just as they are for the disabled. Title VII of the Civil Rights Act of 1964 offers broad protections to the religious. However, the courts have been equally strict about not allowing one employee to create a hostile work environment for others by harassing them about what they do or don't believe" [4]. Additional caution must be considered so that spirituality is a sincere development of the worker and not a way to exploit and coerce workers.

SPIRITUALITY AS A COURSE OF STUDY WITHIN A BUSINESS TRACT

Can spirituality be taught? In some sense, every person has a spiritual center, it just needs to be recognized and encouraged. There are several accredited higher learning centers which are implementing courses in workplace spirituality: Harvard Business School; The University of New Haven; The University of Denver; The University of St. Thomas. There are an abundance of website areas and reading texts on the subject as well. Perhaps in conjunction with an Ethics or Human Resource course, more colleges and universities could introduce spirituality as a course of study.

SWOT ANALYSIS

The SWOT Analysis in Figure 8 assists to sum and conclude our research:

SWOT ANALYSIS

STRENGTHS	WEAKNESSES
Encourages ethics, service; Emphasizes holistic self; Team building; Improves communication;	Lacks easy measurable impact on and relationship to the bottom line; "numbers" people skeptical;
OPPORTUNITIES	**THREATS**
Use a different term; Leadership "bulletins"; Education; HR intro's;	Perceived as trite and soft; Thought of as repetitive of other ideas (i.e., "7 Habits"); HR concerns;

FIGURE 8

CONCLUSION

Developed throughout this research was the idea of spirituality as a viable part of business strategy leading to measurable bottom line results. Strategic planning and spirituality were each defined; the current atmosphere of today's organization (doing more with less) with resulting employee dissatisfaction was explained. This confirmed the necessity for workplace spirituality (value, meaning, purpose) as beneficial to employees and ultimately to the organization. Primarily resting on KeySpan, SWA examples and Kenny Moore's interview, spiritual methods and benefits were hi-lighted. Charts explained the evolution of spirituality in business, depicted a comparison of American and Japanese cultures and paralleled Kenny's and Deming's spiritual points. Analytical tools (Balanced Scorecard, Balanced Needs Scorecard) were discussed as necessary to gauge the workplace climate. Ethical considerations of workplace spirituality without infringing upon worker beliefs and rights were emphasized. As a newly considered discipline, the material for this topic was bountiful yet was limited to fit these pages. This research is concluded with Kenny's interview exhortation to be "ambassadors for the sacred" along with his words from The CEO and The Monk: "The Divine's invitation to us is to get in there and be a player as the drama unfolds . . . Business has a tremendous force for good in the world . . .the opportunity is ever present. We who labor there have a direct influence on the outcome. And our impact has the potential to be dramatic . . .'If you think you're too small to be effective, then you've never been in bed with a mosquito' (Kenny quoting his spiritual advisor, Father Theodore)" [3, p.237].

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TWO TRENDSETTERS IN MODERN MANAGEMENT

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ABSTRACT

This paper presents an analysis/discussion of Peter Ferdinand Drucker, "The Father of Modern Management" and Stephen Covey, "The Man Who Dedicated His Life to Teaching Principle-Centered Living and Leadership". These two men have had a significant impact on today's corporations. These men shared similar beliefs and ideas: employees are interested in personal achievement and personal responsibility." Stephen Covey refers to Peter Drucker as, "the renaissance man of the field of management, one of the greatest management thinkers of our time."

INTRODUCTION TO PETER DRUCKER

Peter Ferdinand Drucker was known as the "Father of Modern Management". He was born in 1909 into a career-minded family in Vienna Austria. His father was an economist and a lawyer, his mother studied medicine. In 1929 he was hired by Frankfurt Germany's largest daily newspaper; his first story was the stock market crash of 1929. He began his career as a writer during a time of great change and hope for an economic world.

In 1939, at the age of 30, he published his first book, *The End of the Economic Man: The Origins of Totalitarianism.* He becomes a prolific writer and became known as the "Father of Modern Management." His life is the story of management, the rise of the modern corporation and the people who organize it. As Intel Corporation co-founder Andrew S. Grove stated: "Like many philosophers, he spoke in plain language that resonated with ordinary managers. Consequently, simple statements from him have influenced untold numbers of daily actions; they did mine over

decades." He was **the** management guru, he didn't like that raises and perks were awarded to mediocre executives as they cut the numbers of the rank and file worker.

Management Style:
Drucker had great hopes for the possibilities of the rising popularity of the corporation. He wanted to build communities and provide meaning for the employees that were working for the corporations. As per James O'Toole, University of Southern California professor, "It is frustratingly difficult to cite a significant modern management concept that was not first articulated, if not invented, by Drucker". Drucker was a forward thinker that brought him to the realization of the idea of decentralization, which was adopted by every large corporation. Even now, companies probably do not realize that they are utilizing concepts first discovered by Peter F. Drucker.

It was his idea that workers should be treated as assets, not liabilities that can be discarded. This idea holds true today, as employees struggle to be part of an organization. When people are treated with respect they realize that they are an asset to the corporation, employee morale and job satisfaction rise, thereby raising productivity. Drucker also made it clear to corporations that there is "no business without a customer," thereby adopting the slogan, "the customer is always right."

In an interview with Fortune Magazine in 2001, Drucker is quoted as saying "The field was based on the asinine assumption that organizations act like individuals. They don't." [1] "Physics sprang from Newton, economics from Adam Smith. And Peter Drucker became the undisputed father of management – the discipline devoted to the study of organizations." [1].

Drucker believed that managers should take an active role in the advancement and education of their employees. What he recognized in effective executives is that they do not waste time. It's like the old saying "if you want something done, ask a busy person to do it", the effective executive "puts first things first" [1].

INTRODUCTION TO STEPHEN COVEY

Dr. Covey earned his undergraduate degree from the University of Utah, his MBA from Harvard, and completed his doctorate at Brigham Young University. While at Brigham Young University, he served as Assistant to the President and was also a Professor of Business Management and Organizational Behavior. He authored the international bestseller, *The 7 Habits of Highly Effective People.* In 2002, Forbes named *The 7 Habits of Highly Effective People* the number one most influential business book of the Twentieth Century. His other bestsellers include: *First Things First, Principle-Centered Leadership, The Seven Habits of Highly Effective Families* and *The Eighth Habit.* His leadership advisory magazine, *Executive Excellence*, is in its eighth year of publication [3].

Dr. Covey is an internationally respected leadership authority, family expert, teacher, organizational consultant, and author. He dedicates his life to teaching principle-centered living and leadership to individuals, families, and organizations.

Covey received several awards throughout his career (Speaker of the Year Award, International Man of Peace Award, International Entrepreneur of the Year Award, and the Thomas More College Medallion. He has been awarded eight honorary doctorate degrees, but Covey claims the most meaningful award that he ever received was the National Fatherhood Award. [3].

Covey's teachings and ideas are not new; in fact, if you read closely you will find many of Drucker's thoughts and beliefs as well as several of St. Joseph's Managerial Abilities.

Covey's book, *"The Seven Habits of Highly Effective People,"* [4] focuses on the three levels or stages of human development: "dependence, independence, interdependence." Covey believes that dependent people need others to get what they want. Independent people can get what they want through their own efforts. Interdependent people combine their own efforts with the efforts of others to achieve their greatest success. Covey explains that there are seven habits that human beings must possess in order to get to the interdependence stage. The seven habits are listed below:

—Habit One: Be proactive. First be self-aware, and then try to understand what others think of you. If you are not happy with what you find, you can make a change; you have free will. You do not need to be reactive; rather you can act from the basis of a well-defined plan. You should look at your surroundings and decide what your circle of influence is as well as what is not in your circle of influence. You must learn to accept the consequences of your actions. Additionally, you must learn to keep your commitments.

—Habit Two: Begin with the end in mind. (This is the principle of personal leadership.) Look at where you want to go, have a vision. Determine what "being successful" means to you. Find out what is really important to you. Covey believes, "All things are created twice. Leadership is the first creation. Management is the second creation. The leader has vision. The manager implements the vision." If you do not plan or have a vision, things will evolve and eventually become out of control. You should develop a personal mission statement. You need to understand your centers: some of us are spouse-centered, family-centered, money-centered, work-centered, possession-centered, friend/enemy-centered or church-centered. Covey believes that once you have created a personal mission statement, you should then create a mission statement for your family, or for your organization.

—Habit Three: Put First Things First. (This is the principle of personal management.) This is where you put your plans into action. You have to be convinced that you will succeed, and then you have to organize your time and activities to lead to your success. You have to learn and refuse to follow distracting leads. Then learn to delegate: to use some one else's time is the best way to maximize yours. But you need to delegate in ways that the people to whom you delegate to can use their knowledge to achieve the goals you want them to achieve. Peter Drucker understood the importance of putting first things first; he recognized that effective executives are people who do not waste time. They are people who can accomplish tasks and make things happen.

Covey believes that once you have achieved the first three habits, a person will reach private victory. The next three habits allow people to reach public victory. Covey spends a great deal of time talking about the emotional bank account. He believes that the most important thing to remember is that you need to build a reservoir of goodwill, also known as the emotional bank account when you deal with

others. Building the emotional bank account is achievable when you listen to people; when you keep your commitments, and when you apologize when the occasion calls for it.

—Habit Four: Think Win-Win (This is the principle of interpersonal leadership.) In any situation that you are involved with, look at the interests of the person you are dealing with. Make it a necessary goal that you both walk away as a winner (in other words, win-win or no deal). Win-win requires character, and a sense of integrity.

—Habit Five: Seek First to Understand, Then to be Understood (This is the principle of emphatic communication.) Covey believes that a leader needs to communicate effectively. He explains that communication is a two-way street. When the communication comes from someone else: listen with care (use emphatic listening) so that you will have a good understanding of the other's situation. In the process you will build goodwill with that person. If you do not listen, you will tend to prescribe a remedy to a situation without understanding all of the facts. Then seek to be understood. This is when the communication goes from you to the other person. You have to communicate effectively. To do that you must communicate in the frame of reference of the person who is listening to you.

—Habit Six: Synergize (Principle of creative cooperation.) Covey explains that the outcome of two people working together at maximum efficiency is greater than the outcome of three people working independently. It takes flexibility and openness to work synergistically. Most great organizations work synergistically. All the members work with a win-win approach in their interrelations. To work synergistically you need to value the differences of others.

—Habit Seven: Sharpen the Saw (Principle of balanced renewal.) This statement is derived from a story about a man who is busy sawing a tree but making little progress. A passer-by asks him how come he is making so little progress. The busy man explains that the saw needs sharpening, but he does not have the time to sharpen the saw. Covey explains that we need to renew ourselves, to act on our physical, mental, social/emotional and spiritual plans in a carefully balanced manner. Essentially we need to reinforce ourselves in our vision. Covey believes that when we sharpen our saw we become a better person.

Covey's latest book, *The Eighth Habit,* was written because Covey believed that the shift from the industrial age to the knowledge worker economy had become so profound. Seven Habits of Highly Effective People was published in 1989, and Covey recognized that the world had drastically changed. He believed that in order for individuals to be effective, people would be required to build on and reach beyond effectiveness. The call for this new age is for greatness and a longing to gain fulfillment, experience passion, and to contribute to society. Covey believed that getting access to these higher levels of human genius and motivation requires a new mindset, a new skill set, a new tool set, *The Eighth Habit. The Eight Habit* is about finding your voice while inspiring others to find theirs.

In *The Eight Habit*, Covey quotes Drucker when he explains the knowledge worker economy. "In a few hundred years, when the history of our time is written from a long-term perspective, it is likely that the most important event those historians will see is not technology, not the Internet, not e-commerce. It is an unprecedented change in the human condition. For the first time, substantial and rapidly growing numbers of people have choices; they manage themselves. Society is totally unprepared for it." Covey refers to the five ages of civilization's voice (hunter/gatherer; agricultural; industrial; information/knowledge worker; wisdom). As each stage unfolded, the previous stage no longer

survived. The prediction is that the knowledge worker age will eventually bring about a downsizing of up to 90 percent of the industrial age workforce. Covey refers to Drucker's comparison of the Industrial/Manual Worker Age with today's Knowledge Worker: "The most important, and indeed the truly unique contribution of management in the 20th century was the fifty-fold increase in the productivity of the Manual Worker in manufacturing. The most important contribution management needs to make in the 21st century is similarly to increase the productivity of Knowledge Work and The Knowledge Worker. The most valuable assets of a 20th century company were its production equipment. The most valuable asset of a 21st century institution whether business or non-business will be its knowledge workers and their productivity." [7].

Covey believes that the problems with today's organizations surface around the fact that managers today are still applying the Industrial Age control model to knowledge workers. This is because many people in positions of authority do not see the true worth and potential of their people and they do not possess a complete, accurate understanding of human nature. They manage people as they manage things. This causes people to stop believing that leadership is a choice. Most people think of leadership as a position and therefore do not see themselves as leaders. Making personal leadership (influence) a choice is like having the freedom to play the piano. It is a freedom that has to be earned, only then can leadership become a voice.

During an interview Covey was asked how Peter Drucker made a difference in his life and in his work. Covey responded that Drucker provided him with a basic understanding of management within the larger context of business, society, economics and history. He further commented that Drucker provided him with the motivation to contribute, to make a real difference and *not* to retire.
Covey was asked what he felt was Drucker's greatest contribution to management, leadership or society. Covey stated that Drucker:

- Was conceptual, intuitive, almost prophetic
- Had common sense, meaningful distinctions
- Helped management become professionals

Covey is quoted as saying that, "Drucker is truly the Renaissance Man of the field of management."When Covey was asked what books, articles or experiences with Drucker have made the greatest impact on him, he responded:

- *The Effective Executive* and film series
- *Management Challenges for the 21st Century*
- Confrontational consulting style

Covey said the following during the interview: "Peter Drucker makes the distinction between a quality decision and an effective decision. You can make a quality decision, but if there is no commitment to it, it won't be effective. There has to be commitment to make a "quality decision" effective. An executive may be highly efficient working with things, but highly ineffective working with people. Efficiency is different in kind from effectiveness: Effectiveness is a results word; efficiency is a methods word. Some people can climb the "ladder of success" very efficiently, but if it's leaning against the wrong wall, they won't be effective. Efficiency is the

value you learn when you work with things. You can move things around fast: you can move money, manage resources, and rearrange your furniture quickly. But if you try to be efficient with people on jugular issues, you'll likely be ineffective. You can't deal with people as if you're dealing with things. You can be efficient with things, but you need to be effective with people, particularly on jugular issues. Have you ever tried to be efficient with your spouse on a tough issue? How did it go? If you go fast, you'll make very slow progress. If you go slow and get deep involvement doing what is necessary through synergistic communication based on a win-win spirit you'll find that in the long run it's fast because then you have total commitment to it. You also have a quality decision simply because you have the benefit of different creative ideas interacting, creating a new solution that is better and more bonding." [2].

COVEY'S APPLICATIONS AT ALTANA, INC.

Founded in 1873 and headquartered in Constance, Germany, ALTANA Pharma AG is the pharmaceutical division of ALTANA AG. ALTANA AG is headquartered in Bad Homburg, Germany and is the management holding company for a pharmaceutical and specialty group. While Germany is the largest single market for ALTANA Pharma AG, the company recognizes that the future lies in foreign markets, particularly the United States and Canada.

Altana Inc. is the managing group for the three New York based divisions of ALTANA Pharma AG: Fougera, Savage Laboratories and Pharmaderm (veterinary division) as well as one Georgia-based division, PharmaDerm.

Fougera is the generic drug division, which primarily produces topical ointments and creams for dermatologic and ophthalmic applications. It is one of the largest manufacturers and distributors of such generic drugs in the United States. Fougera has been in business for more than 150 years, entering the generic market in 1966. Through experience, broad technical ability and single-minded dedication, Fougera has set the standard for quality, dependability and value. Today, as a result of this, Fougera is one of the largest manufacturers and distributors of a wide range of multi-source topicals and ophthalmics in both prescription and over-the-counter dosage forms. Fougera has two sales teams, an institutional sales team focusing on products used in the emergency room and critical care setting. The Fougera Institutional Team promotes CroFab®, the first ovine-derived antivenom, DigiFab® an antidote for digoxin toxicity as well as many of the Fougera foilpac® products. In less than one year on the market, CroFab® emerged as the market leader providing annual revenues of over $45 million. The National Account team is responsible for all of the Fougera topical products, promoting them to the retail arena (CVS, Walgreens, Rite Aid, etc.).

Savage Laboratories has an array of products. These are obsolete products that require little promotion. This division remains intact for revenue streams only. There are no employees that work for Savage Laboratories.

Pharmaderm Animal Health, the veterinary division, produces a variety of ophthalmic and dermatologic preparations for animal care. The majority of items produced by Pharmaderm

Animal Health are prescription drugs, which can only be dispensed by licensed Veterinarians. Pharmaderm Animal Health is a small division, with approximately five employees.

PharmaDerm (based in Altana, GA) is the branded dermatologic division. PharmaDerm's goal is to become the leading pharmaceutical company in the field of dermatology. They have a sales team of 65 representatives based across the US who promote branded products and call on dermatologists. PharmaDerm is constantly looking for new and innovative products that they can offer the dermatologic community.

Altana Inc.'s mission is prominently displayed throughout the organization. The mission is to serve the public health by developing, manufacturing and marketing high-quality topical drug products as well as developing innovative specialty products. Altana Inc. prides itself as being the number one organization in the industry to consistently bring innovative products to the market place. The company is well known and well respected in the industry.

Values are also prominently displayed in the workplace. Altana Inc.'s values are as follows:

- Walk the Talk
- Take the Banner and Empower our People
- Design the Future
- Drive and Reward Performance
- Manage Customer Satisfaction
- Communicate openly and with mutual respect

These values are similar to Covey's Habits of Highly Effective People. Covey focused on three important areas: having a vision or a plan to determine who/where you want to be; being able to work well with others which includes effective listening and communication, treating people with respect, having empathy, recognizing others; and self reflection which leads to development and improvement. It is these very principles that Altana's values were created from. Designing the future (having a plan/vision), working well with others (empowering people, rewarding performance, managing customer satisfaction, communicating openly and with respect) as well as self-reflection or being able to walk the talk.

Covey was also concerned with people in positions of authority not being able to see the true worth and potential of their people and not possessing an accurate understanding of human nature. His concern was that today's Managers manage people as they manage things. This causes them to stop believing in leadership as a choice. Covey believes that people think of leadership as a position and, therefore, do not see themselves as leaders. Leadership, to Covey, is a freedom that has to be earned.

Altana Inc. spends a great deal of time and money when it comes to developing its management team. There are rigorous management development programs that Altana has in place. Leadership development is key and there are a number of seminars, books and training sessions that managers attend on a regular basis. This enables new managers to understand the importance of continual development and growth as well as providing

ongoing programs for existing managers who are not new to the role. These leadership development programs focus on many of Covey's principles.

Covey has had a tremendous impact on the successful and profitable outcome that Altana Inc. has had throughout the years. Altana Inc. is one of many organizations with values and guiding principles that mirror the eight habits that Covey preaches. What is unique about Covey's habits is that they are beneficial to the individual person. His habits enable a person to make a positive change in his/her personal life. This positive change then carries over to the professional life. A cascading effect follows; one person changes his/her behavior and suddenly others follow the lead. Of course, the largest impact occurs when the people at the top of the organization enforce a positive behavior or leadership style. Behaviors that are displayed at the top of the organization trickle down to every level. Altana Inc. is fortunate that the CEO and Board of Directors believed in Covey's philosophies and demonstrates them on a consistent basis. These behaviors led to the successful growth that Altana Inc. has realized year after year.

CONCLUSION

After researching and learning about these two trendsetters in the management world, it is evident to see why people would want to mirror their behaviors. Drucker's and Covey's ideas and management styles are such that every organization and every individual should apply their philosophies in the workplace as well as to their every day lives. They have wonderful time-tested beliefs that can positively influence any environment and we all have the resources to successfully implement their techniques. Altana Inc. is a perfect example of how an organization can be profitable, growing, and well respected by adhering to the thoughts and philosophies of these great leaders.

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USE INTERNAL MARKETING TO IMPROVE EMPLOYEE'S ORGANIZATIONAL COMMITMENT

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ABSTRACT

This research adopts a cross-sectional study to investigate staffs' perception of internal marketing and organizational commitment of three regional teaching hospitals in Taiwan. Research samples are staffs of three hospitals including the administrative department, medical department, medical technology department, and nursing department. The survey sample includes 350 questionnaires were distributed, resulting in 288 valid questionnaires being returned. The valid return rate for the survey is 82.29%. The results of study show a positive correlation between organizational commitment and internal marketing, and the age, professional title and seniority will influence staff's perception on organizational commitment and internal marketing.

Key words: Hospital Management, Internal Marketing, Organizational Commitment, Job Satisfaction, Human Resource Management

INTRODUCTION

In 1995, Taiwan implemented its national health insurance system, thus adding a third party—Bureau of National Health Insurance—to the simple two-sided relationship between health service providers and users. A trilateral exchange relationship mode was thus established in Taiwan's health care system. The percentage of citizens covered by the national health insurance in Taiwan reached 96.16% in 2001. Meanwhile, the proportion of national health expenditures (NHE) to the gross domestic product (GDP) increased from 3.40% in 1980 to 5.77% in 2000 and seems to keep growing [1]. To meet daily growing medical care expenses, medical care authorities had to adjust their policies on medical coverage and insurance premiums, which in turn, influenced the operations strategies of medical institutions and their services. As an indirect consequence, they also influenced the relationship between medical institutions and their patients. The medical service system in Taiwan is controlled by a government organization, the health insurance agency, and numerous other private organizations, which can display the exchange features of a network market. In effect, they form a multilateral exchange relationship. The quality of medical care provided by medical institutions and their source of income are thus influenced not just by medical care policies adopted by government authorities but are also swayed by regulations of the medical insurance system. The costs of providing medical services are regulated by the medical insurance system, prompting medical institutions to pay importance to resource allocation efficiency and better service quality for patients. Under the dual pressure to control costs while maintaining quality of service, medical institutions often face administrative and management challenges. Owing to the changing medical environment in Taiwan, to improve and maintain hospital performance, hospital administrators recently have devoted themselves to improving the relationship between patients and service providers, and to considering methods of improving hospital service quality to satisfy patient demands and enhance patient loyalty.

Greene et al.[2] proposed that service organizations should pay increased attention to internal marketing, because service processes generally maintain contact with customers via their employees[3], most service industry organizations are highly labor-intensive and internal marketing is helpful for such organizations in attracting and ensuring high involvement of high quality talent [4]. Internal marketing practices aim to attract and retain the most qualified and committed employees for organizations. In a service-providing organization, this translates into eliciting service-oriented behaviors designed to achieve high customer satisfaction and loyalty [5]. Bansal et al. posited that internal marketing can improve employee organizational loyalty and job satisfaction [10]. Previous empirical research has identified a positive correlation between employee's job satisfaction and organizational commitment [6].

Research Objectives and Importance of the investigation Significance

Studies on internal marketing primarily adopt the service industry as the research object, but most researchers still view commercial organizations as the research object. However, administrators of nonprofit organizations, such as hospitals, should pay greater attention to improving internal management process, for example through downsizing, reorganization, and so on, owing to the influence of changes in medical environment and health policy. Cooper & Cronin [7] though focused on nursing home care and their focus was limited to internal marketing activity, but the main goal of internal marketing is to enhance service quality for external customers [8].According to the service-value chains [9], internal and external customer satisfaction should be included in other mediator variables. Restated, organizations can through promoting internal marketing, improve internal customer satisfaction and thus improve external customer satisfaction [10].

Internal Marketing

During the early 1980s, the concept of internal marketing first appeared in the service marketing literature [4,5,11,12,13,14,15].Internal marketing is one of the methods for human resources management [16]. It proposes the use of motivation, mobilization, co-opting and management of personnel to retain their services and serve external clients in ways that are constantly improving [12]. Tansuhaj et al. [3] believe that internal marketing stresses various plans that emphasize employee

development and that a complete internal marketing program must necessarily include employee recruitment, training, encouragement, communication and retaining activities that lead to changes in employee attitudes and behavior. In other words, internal marketing is a company's human resources management activity for the successful hiring, training and encouraging of employees, and providing better services to clients [13]. George & Grönroos [17] more clearly point out that internal marketing is a philosophy of managing human resources from the marketing perspectives. Collins et al. [18] contrasted the 4Ps of marketing with HR management activities. They posit that products are the HR products (HR services, classes, programs, etc.). Price is converted set price, fund allocation and opportunity cost. Place (channel) is the locale for providing services or the mode of transmission used. Promotion is communication with the client (mainly through meetings and documents). Still, other scholars think that internal marketing must be viewed in terms of organizational behavior. They believe that internal marketing is a social process [19] and that it can be used to make employees acquire more positive work attitudes, such as commitment to the organization, dedication, encouragement and satisfaction [3]. Companies can take advantage of internal marketing to make organization members adjust their behavior such that they gradually become more customer- and service-oriented, thereby providing clients with products and services that better meet their needs [20].

Organizational commitment

The extensive body of scientific studies on organizational commitment, largely focused on organizational behavior/psychology, has produced various definitions of the factor construct and considerable discussion of its development, consequences, and measurement [21]. At a general level, most researchers agree that organizational commitment describes a psychological state that characterizes the relationship of an employee with the organization for which they work and that has implications for their decision to remain with the organization [22]. Organizational commitment comprises employee attachment to their organization [23, 24]. Meyer and Allen [25] have identified three types of organizational commitment. Affective commitment describes individual emotional attachment, identification with, and involvement in a particular organization. Furthermore, continuance commitment reflects employee awareness of the costs of leaving an organization. Finally, normative commitment reflects individual sense of obligation to remain in an organization.

The Relationship between Internal Marketing and Organizational commitment

Internal marketing is based on the notion that organizations providing secure employment are committed to their workforce [26]. Additionally, the theory of reciprocity suggests that this commitment should be returned by employees by demonstrating enhanced job satisfaction and trust in management [27]. Thus, firms can use internal marketing activities to improve employee job satisfaction [10].

Beside, internal marketing emphasizes that firms can hire employees who can be eligible for the organizational mission of business management to provide employees with clear vision and goals and improve the design of human resource management [8]. Organizational commitment indicates the degree to which individuals are emotionally attached to the organization and identify with organizational goals [28]. Commitment thus involves a desire by employees to consider the interests of their organization, and to want to perform the activities necessary for quality improvement [29]. Internal marketing assume that organizations, through internal marketing activities, can improve the job satisfaction of internal customers. Previous studies have established that employee organizational commitment is positively correlated with job satisfaction [30,31, 32]. When employee job satisfaction is enhanced, employee adopts a positive attitude when serving external customers, a situation that can help to improve service quality for customers.

According to the research framework (see Figure 1), the hypotheses of this study are: H1. Employee demographic variables influence the perception of internal marketing. H2. Employee demographic variables affect the perception of organizational commitment. H3. Internal marketing is positive correlated with organizational commitment.

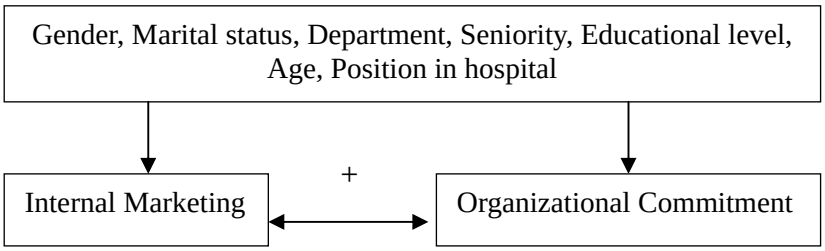

Figure1 Theoretical framework of internal marketing and organizational commitment

METHODOLOGY

Sampling

This work adopts a cross-sectional study to investigate the employees of three district hospitals in Taiwan. The survey sample includes all employees of the sample hospitals, including administrative, medical, medical-technology and nursing staff. 350 questionnaires were distributed, resulting in 288 valid questionnaires being returned. The valid return rate for the survey is 82.29%. The survey period ran from February 1 to March 9, 2006.

Data Collection

Internal Marketing. This work is implemented by a questionnaire survey using the 7- point Likert scale. Money & Foreman [33] adopted a case research approach to develop internal marketing survey tools, took two samples as the research object, applied the same questionnaire to both samples, and set the Cronbach's values of the questionnaire to 0.942 and 0.948, a scale which has subsequently become the standard [34]. This investigation uses the questionnaire designed by Money & Foreman [33].**Organizational Commitment.** Organizational commitment (OC) was measured using the fifteen-item version of the Organizational Commitment Questionnaire [24]. This work uses the questionnaire developed by Mowday et al.. **Demographic Questionnaire.** Data were collected on respondents' age, department, educational level, marital status, position in hospital, gender, and seniority.

RESULTS AND DISCUSSION

Descriptive Statistics

This investigation presents the mean and standard deviation of hospital employee perceptions of internal marketing, and organizational commitment. The mean value of internal marketing in the hospital lies between 4.8-4.4. Moreover, the mean value for employee's organizational commitment lies between 3.02 and 4.78.

Inferential Statistical Analysis

This study adopts One-way ANOVA to explore the effect of demographic variables on internal marketing, and organizational commitment. Furthermore, by focusing on the analytical results produced by one-way ANOVA, this work implements a Scheffe Post-Hoc comparison by focusing on the results with significant variance. Cooper & Cronin [7] know that demographics (including age, gender, education and working experience) are influence nurses' perception of internal marketing. This study finds that age affects employee perceptions of internal marketing. Within employee perceptions of internal marketing, subjects aged 30-39 years old are significantly stronger high than are group members aged below 20. Among different position in hospital, director rankers exhibit

stronger perceptions of internal marketing than do ordinary employees. Director rankers generally become involved in creating strategy projects and policies of human resource management systems for hospitals. Consequently, they have stronger perceptions of internal marketing than ordinary employees.

Researchers found that demographics affect organizational commitment [35, 29]. This research found the department variable affects employee responsiveness to organizational commitment. The degrees of organizational commitment within medical care departments exceed those of administrative departments. This phenomenon possibly occurs because the personnel of medical care departments are the main service providers of health care services and deal with patients directly with high emphasis on service quality commitment from hospital management departments easily. Naturally, the remuneration of doctor is much better than that of ordinary administrative staff in Taiwan. Thus, they display higher organizational commitment than administrative staff. Conducting relevant analysis with Person correlation, when α=0.01, the coefficient correlation value for organizational commitment between internal marketing is 0.478(P=0.000).

CONCLUSIONS AND IMPLICATIONS

The results indicate that employees believe that internal marketing activities must include establishing a clear management vision, providing a good workplace to employees, providing training and development, motivating and controlling employees, and retaining employees and so on, all of which are important to hospital administrators. We find that employee perceptions of organizational commitment are correlated with their perceptions of internal marketing. We recommend that hospital administrators can enhance their internal marketing activities to improve employee perceptions of organizational commitment. The results show us that health care service providers exhibit stronger perceptions of organizational commitment than administrative staff. This difference possibly exists because except for administrative directors, the salary and welfare of medical care givers generally exceed those of ordinary administrative staff. This salary gap exists because the said medical care givers are professional talent who has profession certificate examinations and is only available for medical care givers to provide professional medical service. We recommend hospital administrators can improve the non salary welfare of administrative staff. For example, education and training activities can be enhanced to improve the professional skills of administrative staffs and provide intrinsic motivation to the said administrative staff.

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A STUDY OF TEAM LEARNING ACTIVITIES IN NPD PROJECT TEAMS - THE MODERATING ROLE OF PSYCHOLOGICAL SAFETY

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ABSTRACT

This study explores team learning activities in NPD project teams from theoretical inquiry and empirical research. The study found that: 1) team members' experiences (including individual experiences and team experiences) have a significant influence on team learning activities (including team discussion, team reflection, and action); 2) team psychological safety does moderate the effect of team members' individual experiences on team reflection and the effect of team experiences on team action, but has no influence on the relationship between team members' experiences and team discussion; 3) team reflection has a significant influence on team performance, but both team discussion and team action have no effect on team performance.

Keywords: Team learning activity, Psychological safety, Team experience, Team performance

INTRODUCTION

New product development requires an integral process in which different functional areas have to cooperate to accomplish common goals. To facilitate this process many firms have employed cross-functional teams as the primary integrating mechanism [1]. A basic logic for adopting a cross-functional team to engage in product development is to bring together specialists with disparate expertise in order to accommodate multiple perspectives and cope with complexity and uncertainty in new product development context. But empirical studies reported that adopting cross-functional team had resulted in mixed effect on product development performance [2] [3]. To explain the mixed results of team approach, many researchers view new product development as a process of learning. For instance, Senge [4] stated that "the team that became great didn't start off great – it learned how to produce extraordinary results". Sarin and McDermott [5] also find that team learning has a strong positive effect on the innovativeness and speed to market of the new products. From this point of view, the effectiveness of team approach depends on the presence and efficacy of team learning behaviors among team members [6].

Although team learning seems to be a viable predictor for performance, it's not a necessary result of cross-functional team settings. The crux shifts to how to promote cross-functional team's learning activities. For instance, Edmondson [7] found some teams failed to engage in team learning because of a lack of team members' perceived psychological safety. This calls for a more fine-grained theoretical and empirical study in refining the relationships between team's contextual factors and its learning activities. Hence, this study will pursue this research agenda by exploring the relationships between team members' experiences and team learning activities and how they are affected by the level of team members' perceived psychological safety.

RESEARCH FRAMEWORK

Edmondson [8] introduces an integral construct relating to the psychological side of team learning, named "team psychological safety", that provides a theoretical orientation to aggregate the characteristics of interpersonal context of a team. The study applies team psychological safety as an integral contextual factor of team-level that distinguishes cross-functional teams conducive to team learning from those not conducive. And, a theoretical model of team learning that cascades team members' experiences, team learning activities, and team performance is proposed, in which team psychological safety enacts a moderating role (see Fig. 1).

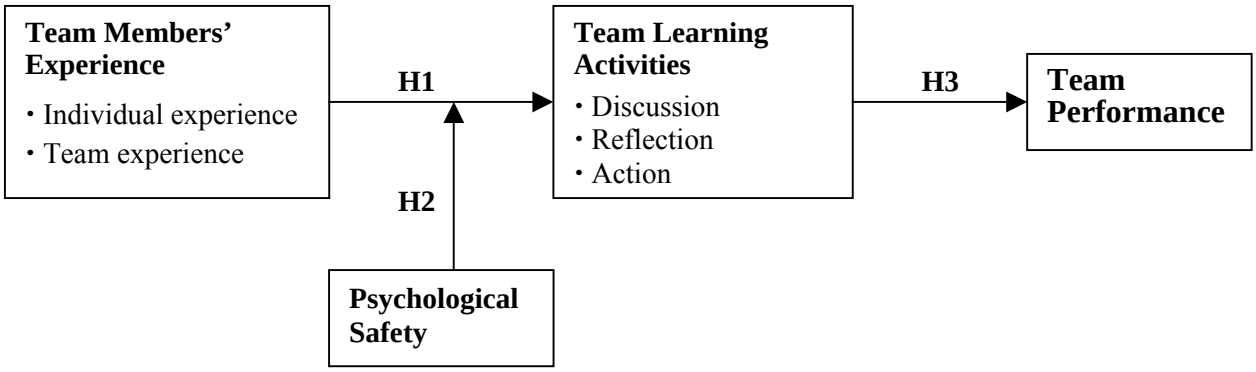

Fig. 1 Research Framework

HYPOTHESES DEVELOPMENT

The Effect of Team Members' Experiences on Team Learning Activity

The foundation of team learning builds on its members' experiences, which including team members' individual experiences and teamwork experiences [9]. A team member's experience is his/her experience of specialist practice that has been fostering in related community of practice [10], and it is what Senge [4] describes as "personal mastery". Learning of a cross-functional team is leveraged greatly by combining team members' disparate knowledge and experiences in the process of engaging the team's common goal. Hence, the study hypothesizes:

H1-1: Team members' individual experiences have a positive impact on team learning activities.

H1-1(a): Team members' individual experiences have a positive impact on discussion.

H1-1(b): Team members' individual experiences have a positive impact on reflection.

H1-1(c): Team members' individual experiences have a positive impact on action.

Team members' team experience is regarded as the aggregate of each member's experiences of working in a team and experiences of working together with other team members in prior work settings. From research of transactive memory system theory, team members' expectations about the distribution of expertise and their familiarity with other members have an important influence on a team's efficacy [11]. Hence, the study hypothesizes:

H1-2: Team members' team experiences have a positive impact on team learning activities.

H1-2(a): Team members' team experiences have a positive impact on discussion.

H1-2(b): Team members' team experiences have a positive impact on reflection.

H1-2(c): Team members' team experiences have a positive impact on action.

The Moderating Role of Team Psychological Safety

As team psychological safety is perceived by all team members and derived from the same shared experiences of all team members, it should converge in a team [8]. Team members are more willing to communicate truthfully and reflect directly on previously undiscussable issues in teams with high team psychological safety rather than in teams with low team psychological safety [12]. Therefore, the positive influence of team members' experiences on reflection and action would be enhanced. In sum, the study predicts that team psychological safety enacts a role of moderating the relationship between team members' experiences and team learning activities, with the exception of the relationship between team members' experiences and discussion. The hypotheses are proposed as following:

H2-1(a): Team psychological safety has no effect on the relationship between team members' individual experiences and discussion.

H2-1(b): Team psychological safety has a moderating effect on the relationship between team members' individual experiences and reflection.

H2-1(c): Team psychological safety has a moderating effect on the relationship between team members' individual experiences and action.

H2-2(a): Team psychological safety has no effect on the relationship between team members' team experiences and discussion.

H2-2(b): Team psychological safety has a moderating effect on the relationship between team members' team experiences and reflection.

H2-2(c): Team psychological safety has a moderating effect on the relationship between team members' team experiences and action.

The Impacts of Team Learning Activity on Team Performance

Brown and Duguid [13] argued that tacit knowledge could be communicated or demonstrated only in direct interaction, and corrected in mutual adjustment between deliverer and recipient, therefore to combine different experts' experiences needs the process of iterative reflection and action. These activities will make team members to suspend assumptions and enter into a genuine "thinking together" [4], which is critical to a team's creative capabilities. Hence, reflection and action would contribute to team performance. Empirical studies [5] [7] also provide supports for the effect of team learning on team performance. Hence, the study hypothesizes the following:

H3-1: By controlling the level of reflection, discussion has no effect on team performance.

H3-2: Reflection has a significant effect on team performance.

H3-3: Action has a significant effect on team performance.

METHODS

The analysis level of this study is at the project level. The study chooses computer and communication industries as the empirical research field because of the fast-paced new product introduction in these

industries and the prosperity of Taiwanese firms in this area. The study compiles a sampling pool consisting of 297 NPD projects coming from 139 firms.

Then, the questionnaire was delivered to each NPD project. The questionnaire includes an introduction of the purpose and process of this study, and requests that the questionnaire to be completed with reference to its team practice. Out of 297 NPD projects, 152 questionnaires were returned. But ten of them were eliminated because of incompleteness and that made the number of usable returned questionnaires down to 142. Hence, the usable response rate is 47.8%.

RESULTS

The reliability of constructs of the study were tested by their Cronbach's α values. All the figures of Cronbach's α values range from 0.78 to 0.88 and indicate that the measurements of this study had an acceptable reliability ($\alpha > 0.7$).

Multiple linear regression analysis was applied to test the hypotheses of the study. Table 1 summarizes the results of tests of the relationship between team members' experience and team learning activity (H1). It shows that individual experience has positive impacts on team discussion, reflection, and action; and that team experience has positive impacts on team reflection and action, but not on team discussion.

Table 1 Regression analyses (H1)

	Model 1	Model 2	Model 3
Dependent variables	Discussion	Reflection	Action
Independent variables			
Individual experience	0.312***	0.403***	0.157*
Team performance	0.008	0.353***	0.613***
Adjusted R^2	0.088	0.481	0.531
N	142	142	142

Numbers are standardized coefficients
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 2 summarizes the results of tests the moderating effects of psychological safety on the relationships between team members' experience and team learning activity (H2). It indicates that psychological safety has a moderating effect on the relationship between individual experience and team reflection, but has no moderating effect on the relationship between team experience and team reflection. A closer examination shows that the impact of individual experience on team reflection is significant higher in high psychological safety situation than in low psychological situation. Table 2 also indicates that psychological safety has a moderating effect on the relationship between team experience and team action, but has no moderating effect on the relationship between individual experience and team action. A closer examination shows that the impact of team experience on team action is significant higher in high psychological safety situation than in low psychological situation. These findings partially support H2.

Table 2 Regression analyses (H2)

	Model 4	Model 5	Model 6
Dependent variables	Discussion	Reflection	Action
Independent variables			
Psychological safety[a] (PS)	0.018	0.043	0.255***
Individual experience (IE)	0.154	0.195*	0.081
Team performance (TE)	-0.114	0.308***	0.416***
PS × IE	0.170	0.289**	-0.028
PS × TE	0.181	0.010	0.180*
Adjusted R^2	0.117	0.512	0.581
N	142	142	142

Numbers are standardized coefficients
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$
Note a: "Psychological safety" is recoded as a dichotomous variable and used as a dummy variable in the regression processes.

Table 3 shows that only team reflection has a significant impact on team performance, while both team discussion and team action have no impact on team performance. Hence, H3 is only partially supported by the results of this study.

Table 3 Regression analyses (H3; Dependent variable: Team performance)

Independent variables	Model 7
Discussion	-0.049
Reflection	0.712***
Action	-0.024
Adjusted R^2	0.457
N	142

Numbers are standardized coefficients
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

CONCLUSION

Overall, the research findings support that team members' experiences have positive impacts on team learning activities, and team psychological safety enacts a moderating role on these impacts except for the impacts on team discussion. This may imply that only in those teams with a certain (high) level of team psychological safety that experienced team members will engage in more team reflection and action. On the relationship between team learning activities and team performance, the study finds that team reflection can enhance team performance while team discussion can't. These results are in line with Edmondson's [8] findings which indicate that team discussion might proceed and result in no in-

depth reflection on the problems being discussed. But the results of this study also reveal that team action has no effect on team performance and are contradictory to Edmondson's [8] findings. A possible explanation is that because many NPD teams usually had a tight schedule to complete the projects, hence many decisions about team action were made whether with a in-depth scrutiny or not. Therefore, the level of team action may has no effect on team performance.

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FORMAT

The consortium will begin with brief opening remarks by the members of the panel among who are a Dean, a Director of a Doctoral Program in Business, a Department Chairperson, and a senior member of numerous appointment, tenure, and promotion committees. All are senior members of the Northeast Region Decision Sciences Institute who have made significant contributions to the vibrancy of the organization over the last 25 years. In addition, all are scholars of note in the Decision Sciences. These opening remarks will be followed by a question and answer session including open discussion with the doctoral students and new faculty.

OBJECTIVE

The central purpose of the consortium is to provide professional contact and guidance to doctoral students and new faculty in business related disciplines. The consortium focuses on:

- advising doctoral students on how to position themselves to win their first academic appointment; and
- advising new faculty on how to survive and flourish in academe including what strategies to follow to achieve tenure and promotion goals.

The consortium will primarily focus on early career development and choosing the initial academic position. It covers issues related to dissertation development, completion of the doctoral program, preparation for job search, interviewing, role of a new faculty member, role of a mentor, course content development, planning for teaching responsibilities, developing a teaching portfolio, developing a research agenda, manuscript submission, interaction with the business community, active membership in national and regional academic and professional organizations, presenting papers, and service activities.

A BAYESIAN ESTIMATION OF MULTIPLE CHANGES IN A TIME SERIES

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Abstract

This paper analyses an autoregressive model subject to changes in both the mean and variance at some unknown points in time. Marginal and conditional posterior distributions of the change points, and the variance ratios are derived when all parameters are unknown. A numerical illustration is provided.

Keywords : Bayesian analysis, change points, change in variance, posterior distribution.

1. INTRODUCTION

Ever since Page introduced the change-point problem in 1954, by studying a switching sequence o normal random variables, a tremendous amount of research papers have been published. Since then, the case of a single structural change has been extensively studied in both classical and Bayesian approaches. From a classical point of view, some important papers on the change-point problem include Page [21], Hinkley [10]), Sen and Srivastava [22], Worsley [25], Hsu [12]. While from a Bayesian perspective, Broemeling [2] [3], Holbert and Broemeling [11], Smith [23], Menzefricke [20], Broemeling and Tsurumi [4], and Carlin et al. [5] have authored some important papers on this topic.

In comparison, a relatively sparse amount of studies have appeared in the literature addressing the issue of multiple structural changes. The multiple change-point problem can arise in many fields including economics, medicine (Johnson et Al, [15]), finance (Kim and Nelson, [18]) and many others. Kim and Engel [17] found multiple changes in variances in real exchange rates while Garcia and Perron [8] found evidence for two breaks in U.S. real interest rates within the unit root context.

With respect to the multiple change-points problem, recent developments in the Bayesian literature include Yao [26] who considered a multiple change in the location under the hypothesis that the joint distribution of the unknown location parameters is exchangeable and does not depend on the change points. Inclan [13] proposed a procedure based on obtaining posterior odds to detect the number of change points in the variance of a sequence of independent random variables as well as a sequence of dependent random variables that follows an autoregressive model. Stephan [24] used the Gibbs sampler to demonstrate how to reduce the computational Bayesian load involved in multiple change-point identification through various models. Chib [7] studied the estimation of a location multiple change points problem within the context of a Markov-switching model. Using the same model, Kim and Nelson [18] considered the identification of a structural

break in postwar business cycles.

Within the classical framework, the multiple change point problem has been addressed by many authors. For example, Inclan and Tiao [14] used cumulative sum of squares method to tackle the multiple variance change-point problem. Chen and Gutpa [6] proposed a binary procedure for testing and locating multiple variance change points in a sequence of independent Gaussian random variables. Addressing multiple structural changes in a linear regression model, Bai and Perron [1] derived consistent and asymptotic distribution results by minimizing the sum of squared residuals. Similarly, Liu, Wu and Zidek [19] considered multiple shifts in a linear model estimated by least squares.

We would say that a sequence of random variables is subject to k structural changes if there exist integers $1 < m_1 < m_2 <\ldots< m_k \leq n-1$ such that observations Y_i ,$i = 1,\ldots,n$, have distinct cumulative distributions $F_j(y,\theta_j)$; $j = 1,\ldots,k+1$. For $j = 1,\ldots,k+1$, θ_j are unknown parameters and the points m_j are called the changepoints.

In this paper, we develop a Bayesian method of estimating the unknown time points where multiple changes in the mean and variance of an autoregressive process occured . This study extends earlier work by Guerbyenne and Kezim [9] and Kezim and Abdelli [16] from a single change point to multiple change points of a sequence of a first order autoregressive process subject to multiple changes in both the mean and the variance at some unknown time points. While Inclan [13] used conjugate priors, noninformative priors are used in this article.The main emphasis is to derive the posterior distributions of the change points and the variance ratios.

2. THE BAYESIAN MODEL

2.1. Model and Assumptions

Consider the following first order autoregressive model with k changepoints in both the mean of the observations y_i and the variance of the errors terms e_i , i=$\overline{1,n}$: $y_i = \mu_j + u_i$ where $u_i = \rho u_{i-1} + e_i$.
where the error terms are independent and normally distributed random variables; that is, $e_i \backsim N(0,\sigma_j^2)$, $i = \overline{m_{j-1}+1,m_j}$, $j = \overline{1,k+1}$, and we use the convention that $m_0 = 0, \quad m_{k+1} = n$. This model can be equivalently reformulated as follows:

$$\begin{cases} y_i - \rho y_{i-1} = \mu_1(1-\rho) + e_i; & i = \overline{1,m}_1 \\ y_{m_j+1} - \rho y_{m_j} = \mu_{j+1} - \rho\mu_j + e_{m_j+1}; & \\ y_i - \rho y_{i-1} = \mu_{j+1}(1-\rho) + e_i; & i = \overline{m_j+2,m_{j+1}} \text{ and } j = \overline{1,k} \end{cases}$$

The vector of changepoints $\underline{m} = (m_1,m_2,\ldots,m_k)'$, the vector of means $\underline{\mu} = (\mu_1,\mu_2,\ldots,\mu_{k+1})'$ and the vector of variances $\underline{\sigma^2} = (\sigma_1^2,\sigma_2^2,\ldots,\sigma_{k+1}^2)'$ are unknown parameters. We assume a constant autocorrelation coefficient ρ but unknown. The vector of unknown parameters is denoted by $\underline{\theta} = \left(\underline{m}',\rho,\underline{\mu}',\underline{\sigma}'\right)' \in \Theta$, where the parameter space is defined as follows:

$$\Theta = \prod_{l=1}^{k}\{2l,\ldots,m_{l+1}-2\}\times\,]-1,1[\,\times\mathbb{R}^{k+1}\times(\mathbb{R}_{*}^{+})^{k+1}.$$

2.2. Prior specifications vector $\underline{\theta}$

Using noninformative priors specifications and assuming independence among all the parameters, the prior distribution of the unknown parameter vector $\underline{\theta} = (\underline{m}', \rho, \underline{\mu}', \underline{\sigma}')'$ is given by : $P(\underline{\theta}) = P\left(\underline{m}, \rho, \underline{\mu}, \underline{\sigma}\right) = P(\underline{m})P(\rho)P\left(\underline{\mu}\right)P(\underline{\sigma})$, where the prior joint mass function of the vector of changepoints $\underline{m}$ is defined as follows: $p(\underline{m}) = p(m_1/m_2,\ldots,m_k)\; p(m_2/m_3,\ldots,m_k)\times\ldots\times p(m_{k-1}/m_k)\times p(m_k)$ since the changepoints $\underline{m}$=$(m_1, m_2,...,m_k)'$ are dependent.

We assume that the vector of changepoints $\underline{m}$ has a uniform prior on the parameter set $\prod_{l=1}^{k}\{2l,\ldots,m_{l+1}-2\}$ such that $p(m_l/m_{l+1},\ldots,m_k) = \frac{1}{m_{l+1-2(l+1)+1}}$; $l = 1,\ldots,k-1$ and $p(m_k) = \frac{1}{n-2(k+1)+1}$. On the other hand, the joint noninformative prior of $\underline{\mu}$ =$(\mu_1, \mu_2, \ldots, \mu_{k+1})'$ and $\underline{\sigma} = (\sigma_1,\sigma_2,\ldots,\sigma_{k+1})'$ are defined (see Box & Tiao, 1973) respectively as follows: $p(\underline{\mu}) \propto$ constant and $p(\underline{\sigma}) \propto \prod_{l=1}^{k+1}\frac{1}{\sigma_i}$ and finally, the autocorrelation parameter ρ has a uniform prior on the open interval (-1,1).

Consequently, the prior distribution of the unknown parameter vector $\underline{\theta} = (\underline{m}', \rho, \underline{\mu}', \underline{\sigma}')'$ is given by :

$$P(\underline{\theta}) \propto \prod_{l=1}^{k}\left(\frac{1}{m_{l+1}-2(l+1)+1}\right)\prod_{j=1}^{k+1}\left(\frac{1}{\sigma_j}\right);$$

where $\underline{\theta} = (\underline{m}', \rho, \underline{\mu}', \underline{\sigma}')' \in \Theta$, while the likelihood function of $\underline{\theta}$ can be written as follows:

$$L\left(\underline{\theta}/\underline{y}\right) \propto \sigma_1^{-m_1}\exp\left\{-\frac{\sum_{i=1}^{m_1}(y_i-\rho y_{i-1}-\mu_1(1-\rho))^2}{2\sigma_1^2}\right\}\times\prod_{j=2}^{k+1}\sigma_j^{-(m_j-m_{j-1})}$$

$$\times\exp-\frac{1}{2\sigma_j^2}\left(y_{m_{j-1}+1}-\rho y_{m_{j-1}}-\mu_j+\rho\mu_{j-1}\right)^2+\sum_{i=m_{j-1}+2}^{m_j}\left(y_i-\rho y_{i-1}-\mu_j(1-\rho)\right)^2\}$$

2.3. Posterior distribution of $\underline{\theta}$

Applying Bayes' theorem through the combination of lhe likelihood function and the prior distribution, the posterior distribution of $\underline{\theta}$ is

$$P\left(\underline{\theta}/\underline{y}\right) \propto \prod_{l=1}^{k}\left(\frac{1}{m_{l+1}-2(l+1)+1}\right)\sigma_1^{-(m_1+1)}\exp\left\{-\frac{\sum_{i=1}^{m_1}(y_i-\rho y_{i-1}-\mu_1(1-\rho))^2}{2\sigma_1^2}\right\}\times$$

$$\prod_{j=2}^{k+1}\sigma_j^{-(m_j-m_{j-1}+1)}\times\exp\left\{-\frac{1}{2\sigma_j^2}\left(y_{m_{j-1}+1}-\rho y_{m_{j-1}}-\mu_j+\rho\mu_{j-1}\right)^2+\sum_{i=m_{j-1}+2}^{m_j}\left(y_i-\rho y_{i-1}-\mu_j(1-\rho)\right)^2\right\}$$

Finally, by setting $A(\mu_1,\rho)=\sum_{i=1}^{m_1}(y_i-\rho y_{i-1}-\mu_1(1-\rho))^2$ and

$$A(\mu_{j-1},\mu_j,\rho)=\left(y_{m_{j-1}+1}-\rho y_{m_{j-1}}-\mu_j+\rho\mu_{j-1}\right)^2+\sum_{i=m_{j-1}+2}^{m_j}\left(y_i-\rho y_{i-1}-\mu_j(1-\rho)\right)^2,$$

the posterior distribution of $\underline{\theta}$ can be rewritten as follows:

$$P\left(\underline{\theta}/\underline{y}\right) \propto \prod_{l=1}^{k}\left(\frac{1}{m_{l+1}-2(l+1)+1}\right)\sigma_1^{-(m_1+1)}\exp\{A(\mu_1,\rho)\}\times\prod_{j=2}^{k+1}\sigma_j^{-(m_j-m_{j-1}+1)}\exp\{A(\mu_{j-1},\mu_j,\rho)\}$$

2.4. Marginal posterior distribution of the changepoints vector and the autocorrelation coefficient

Theorem 1

- *The marginal posterior distribution of the vector of changepoints $\underline{m}$ is :*

$$P\left(\underline{m}/\underline{y}\right)=\begin{cases}\int_{\mathbb{R}^k}\int_{-1}^{+1}P\left(\underline{m},\rho,\underline{\mu}/\underline{y}\right)d\rho d\underline{\mu} & \text{if } \underline{m}\in\prod_{l=1}^{k}\{2l,\ldots,m_{l+1}-2\}\\ 0 & \text{otherwise}\end{cases}$$

- *The marginal posterior density of the autocorrelation coefficient ρ is :*

$$P\left(\rho/\underline{y}\right)=\begin{cases}\sum_{m_k=2k}^{n-2}\cdots\sum_{m_j=2j}^{m_{j+1}-2}\cdots\sum_{m_1=2}^{m_2-2}\int_{\mathbb{R}^k}P\left(m_1,\ldots,m_k,\rho,\underline{\mu}/\underline{y}\right)d\mu_k & \text{if } \rho\in\,]-1,+1[\\ 0 & \text{otherwise}\end{cases}$$

where $\underline{\mu}=(\mu_1,\mu_2,\ldots,\mu_k)'$ and the joint posterior distribution of $\underline{m}$, ρ and $\underline{\mu}$ is defined by

$$P\left(\underline{m},\rho,\underline{\mu}/\underline{y}\right)=\left\{\begin{array}{l}\left(1+(n-m_k-1)(1-\rho)^2\right)^{-\frac{1}{2}}\prod_{l=1}^{k}\left(\frac{1}{m_{l+1}-2(l+1)+1}\right)\\ \times\dfrac{\Gamma\left(\frac{m_1}{2}\right)}{\left[m_1(1-\rho)^2(\mu_1-\widehat{\mu}_1(\rho))^2+(m_1-1)S_1^2(\rho)\right]^{\frac{m_1}{2}}}\\ \times\dfrac{\Gamma\left(\frac{n-m_k-1}{2}\right)}{\left[\frac{(n-m_k-1)\rho^2(1-\rho)^2}{1+(n-m_k-1)(1-\rho)^2}\left(\mu_k-\overline{\mu_k(\rho)}\right)^2+(n-m_k-2)S_k^2(\rho)\right]^{\frac{(n-m_k-1)}{2}}}\\ \times\prod_{j=2}^{k}\dfrac{\Gamma\left(\frac{m_j-m_{j-1}}{2}\right)}{\left[\left(1+(m_j-m_{j-1}-1)(1-\rho)^2\right)\left(\mu_j-\widehat{\mu}_j(\mu_{j-1},\rho)\right)^2+\right.}\\ \left.\frac{(m_j-m_{j-1}-1)\rho^2(1-\rho)^2}{1+(m_j-m_{j-1}-1)(1-\rho)^2}\left(\mu_{j-1}-\overline{\mu_{j-1}(\rho)}\right)^2+(m_j-m_{j-1}-2)S_j^2(\rho)\right]\end{array}\right.$$

with $\widehat{\mu}_1(\rho)=\frac{\sum_{i=1}^{m_1}y_i-\rho y_{i-1}}{m_1(1-\rho)}$ *being an estimator of* μ_1 *based on the first* m_1 observations*;*

$$(m_1-1)S_1^2=\sum_{i=1}^{m_1}(y_i-\rho y_{i-1})^2-\frac{\left[\sum_{i=1}^{m_1}y_i-\rho y_{i-1}\right]^2}{m_1}$$

$$\widehat{\mu}_j(\mu_{j-1},\rho)=\frac{y_{m_{j-1}+1}-\rho y_{m_{j-1}}+\rho\mu_{j-1}+(1-\rho)\sum_{i=m_{j-1}+2}^{m_j}(y_i-\rho y_{i-1})}{1+(m_j-m_{j-1}-1)(1-\rho)^2};\quad j=\overline{2,k+1}$$

and $\widehat{\mu}_j(\mu_{j-1},\rho)$ *being an estimator of* μ_j *conditional on* μ_{j-1} *and* ρ*.*

Furthermore, for $j=\overline{2,k+1}$ *and if* $\rho\in\,]-1,1[^*=\,]-1,1[\setminus\{0\}$, we have

$$\overline{\mu_{j-1}(\rho)}=\frac{\sum_{i=m_{j-1}+2}^{m_j}(y_i-\rho y_{i-1})-(m_j-m_{j-1}-1)(1-\rho)(y_{m_{j-1}+1}-\rho y_{m_{j-1}})}{\rho(1-\rho)(m_j-m_{j-1}-1)},$$

$$(m_j-m_{j-1}-2)S_j^2(\rho)=\sum_{i=m_{j-1}+2}^{m_j}(y_i-\rho y_{i-1})^2-\frac{\left[\sum_{i=m_{j-1}+2}^{m_j}(y_i-\rho y_{i-1})\right]^2}{m_j-m_{j-1}-1}$$

.

3. A SIMULATION STUDY

We have carry out simulations to illustrate the distributions of the changepoints. We are

assuming two changepoints with three changes in the mean of the observations and variance of the error terms, and a constant autocorrelation coefficient. In this section we will

present the simulation results for estimating the true changepoints m_1 and m_2 using the mode and mean a posteriori. We consider the following model: $y_i = \mu_1 + u_i;$ for $i = \overline{1, m_1}$; $y_i = \mu_2 + u_i;$ for $i = \overline{m_1 + 1, m_2}$; $y_i = \mu_3 + u_i;$ for $i = \overline{m_2 + 1, n}$; where $u_i = \rho u_{i-1} + e_i;$ for $i = \overline{1, n}$; and the error terms e_i , i = $\overline{1, n}$, are such that: $e_i \backsim N(0, \sigma_1^2);\ \ i = \overline{1, m_1};\ e_i \backsim N(0,\ \sigma_2^2)$; $i = \overline{m_1 + 1, m_2}$; and $e_i \backsim N(0,\ \sigma_3^2)$; $\ \ i = \overline{m_2 + 1, n}$

We simulated 1,000 samples of size 100 assuming two changepoints at m_1= 30 and m_2 = 70 given $\mu_1, \mu_2 = 1.2$ and $\mu_3 = 1.5$, $\sigma_1 = 0.5, \sigma_2 = 1, \sigma_3 = 2$, and a constant coefficient of correlation $\rho = 0.5$. Figures 1 and 2 show the frequency distribution of the posterior mode of the two changepoints $m_1$and m_2. Besides estimating the changepoints using the posterior mode, we also obtained the frequency distribution of the posterior means for the two changepoints m_1 and m_2. Figure 3 and figure 4 displays their respective frequency distributions.

The frequency distribution of the posterior means for the two changepoints m_1 and m_2 exhibit more variability than those corresponding to the frequency distribution of the posterior modes for the two changepoints. Clearly, we observed that the posterior mode seems to provide better results than the posterior mean in estimating the changepoints.

Overall, in our simulation study, we noticed also that first, as the changes in variances increase, the probability of detection becomes higher. Second, changes in variances are well detected when both sample size and observations between changes get larger. We observed similar results for the ratio of variances. Even for sample size as small as 20, similar results were obtained, but the root mean square error decreases as the sample size increases.(Figures 1-4 and the complete analysis are available upon request).

References are available upon request from kezimb@merrimack.edu

FORECAST MODELING FOR COMPLEX PROCESSES: A WASTEWATER APPLICATION

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ABSTRACT

We compare the predictive ability of linear ARIMA models to nonlinear time delay neural network (TDNN) models. Using a variety of artificially generated nonlinear ARIMA data sets, as well as two real world wastewater data sets, we provide preliminary results that appear to demonstrate that neural networks do not always provide the best solution. While the TDNN worked best for the limited real-world cases we examined, for the artificial data sets they did not always perform better than linear ARIMA.

INTRODUCTION AND LITERATURE REVIEW

Prior research establishes that autoregression is common in many processes, including wastewater treatment (Alwan and Roberts, 1995; Kim and May, 1994; Berthouex *et al*., 1978). This has motivated a number of studies on the use of linear ARIMA models for process control applications (Apley and Tsung, 2002; Mastrangelo and Forreset, 2002; MacCarthy and Wasusri, 2001; Weighell *et al*., 2001). Many process observations are also complicated by nonlinearity in the time domain or may involve nonlinear interactions between variables. Consequently, neural network modeling is being extensively studied in nonlinear applications (Ramirez-Beltran and Montes, 2002; Yu and Gomm, 2002), including wastewater treatment (West, *et al*., 2000; Pu and Hung, 1995). Many of these studies report that neural networks are superior to traditional parametric statistical methods in process modeling and control. The wastewater research literature acknowledges the complex nature of this process with a variety of research efforts aimed at a better understanding of its variation, leading to better control. The literature has focused on a variety of measures in relation to autocorrelation and non-linearity. Studied measures include: Ammonia (Boger 1997), Chemical Oxygen Demand (COD) (Fu and Poch, 1995), Nitrogen (Choi & Park 2001), Biochemical Oxygen Demand (BOD), Suspended Solids, and fecal coli form (Cinar 2005). While some researchers have compared various models for predictive effectiveness, most that report on wastewater modeling today make the *de facto* assumption that neural networks are always superior to traditional linear statistical models. Hamed, *et al*., (2004) state that, "the complex physical, biological and chemical processes involved in wastewater treatment process exhibit non-linear behaviors which are difficult to describe by linear mathematical models." The trend lately is toward case studies in wastewater control that document the effectiveness of a particular neural network approach or several neural network modeling approaches in favor of comparing various approaches (Grieu, *et al*., 2005; Cinar 2005; Zamarreno, *et al*., 2000). Some studies have compared linear methods to neural networks and neural networks to each other. For example, Zhu, *et al*., (1998) compared a TDNN

to a Multi-Layer Perceptron (MLP) neural network for modeling of a wastewater system. Their study found the TDNN superior to the MLP using a simple correlation coefficient comparison. None of the aforementioned studies investigated the efficacy of models beyond one period into the future. Multi-step forecasting for the purpose of watershed environmental quality management was not a consideration. All of the studies focused on the more immediate issue of process control. In addition, none seem to account for autoregression in their regression-based models. Further, many continue to use the standard MLP neural network, which appears to be inferior to the TDNN neural network. In our study we investigate a wide range of data sets, involving artificial and real wastewater data, for the purpose of better understanding the appropriateness of selected linear and nonlinear modeling approaches. We employ artificial data sets that are nonlinear and autoregressive as well as two real world data sets from actual wastewater treatment facilities. We investigate BOD, Suspended Solids, Nitrogen and Phosphorus for both single-period forecasting for short lead-time process control and multi-period forecasting for longer lead-time watershed environmental quality management.

PREDICTIVE MODELS FOR WASTEWATER QUALITY MANAGEMENT

Linear ARIMA is a fairly well-known modeling approach. The reader is referred to Vandaele (1983) for a description of this approach. The artificial neural network is a nonlinear regression technique that builds a predictive model by learning to recognize patterns in historical data. The patterns in historical data can exist in both spatial and temporal domains. A network with a short term memory is required in this study to model temporal patterns. A central issue is the design of an appropriate short-term memory structure to model time in the neural network structure. The most common solution is to use a snap shot representation where the input signal undergoes segmentation in a preprocessor. This strategy results in the time delay neural network or TDNN (Waibel *et al*., 1989; De Vries *et al*, 1992).

The structure of the TDNNs considered in this study consisted of two input nodes, one output node, and a number of hidden layers. In all cases the nonlinear activation function used was the hyperbolic tangent. We ran several models with varying numbers of hidden layers and selected the best for comparison to the best linear ARIMA models.

DATA DESCRIPTION AND EXPERIMENTAL METHODOLOGY

Artificial Autoregressive Nonlinear Data

The artificial data is designed to be representative of wastewater process control data that frequently contain autoregressive correlation structures with a one period lag and nonlinearities. Eight different groups of artificial data sets representing a mix of nonlinear first order autoregressive observations and moving average observations were used. Most contain pure autoregressive (AR) correlation structures, the primary focus of this study, while others have mixed AR and MA components. The reader is directed to Zhang, Patuwo and Hu (2001) for details on these models. Each data set is constructed from the eight models with $\varepsilon_t = N(0,1)$. A total of 3,000 observations are generated. Each artificial nonlinear time series model data set was run three times using different random seeds for the error term.

Wastewater Treatment Process Data

Our research findings for artificial data are extended by studying two real world data sets that are known to be nonlinear and autoregressive. For this purpose wastewater treatment data from Greenville, North Carolina, USA is used as well as data reported by Poch, *et al*. (1993). The Greenville data consists of 730 daily observations of wastewater effluent levels of nitrogen and phosphorus. The Poch wastewater treatment data used in this study consists of 638 daily measurements of several input, process state, and effluent properties of an urban wastewater treatment plant. The particular variables used in our study included BOD and Suspended Solids.

Experimental Design

The experimental results were generated for a series of predictive cycles. A model was estimated from a fixed window of data and predictions made for five periods forward in time. For the artificial data sets, each ARIMA model and each TDNN model was repeatedly estimated using a moving window of training data. We used a window size of 100 observations. The window advances through the data, creating a number of prediction cycles. For example, the first cycle uses observations 1 to 100 to estimate models and generate predictions for periods 101-105. The window then advances and observations 2 through 101 are used to estimate models for the second cycle. The data window iteratively moves through the data set generating multiple cycles of estimation and prediction. A total of 2,340 cycles were generated to analyze the artificial data sets. The preferred ARIMA models estimated were AR(1) and the preferred TDNN models were constructed with two input nodes, four hidden nodes, and one output node. The wastewater treatment models for the real data sets were also estimated from moving windows of 100 data observations. As with the artificial data, the ARIMA models were generally AR(1) and the TDNN models consisted of two input nodes, four hidden nodes, and one output node. The potential effectiveness for wastewater applications is gauged by measuring the distance of each prediction from the corresponding actual value to determine an error. The predictive accuracy of each model is measured by the mean absolute error (MAE) and mean squared error (MSE).

ANALYSIS AND RESULTS

Model Results for Artificial Times Series Data

The results for the ARIMA and TDNN models tested on the eight groups of artificial data are presented in Table 1. We first discuss the one period results averaged over all prediction cycles. For ease of presentation, only MAE results are discussed. Time was available to run selected ***t***-tests and it was generally found that any apparent difference shows up significant for ***t***-testing. For example, examining a one period prediction, the TDNN is more accurate for ***t***-testing than the linear ARIMA models in the cases of SAR, TAR, and STAR1. There is no significant difference in one period prediction for ***t***-testing between TDNN and ARIMA for the NAR case. By inference, for the single period case of BL2, the ARIMA and TDNN models appear similar, while for the NMA case, the TDNN appears to outperform ARIMA. It may be inferred for the one period case that ARIMA and TDNN perform equally for the cases of BL1 and STAR2. In general, the TDNN models appear to outperform the ARIMA models for one period prediction in about 4 or 5 of the 8 cases, while the ARIMA models never appear to outperform the TDNN models (except possibly in the STAR2 case).

Selected paired *t*-tests were used to compare average errors for the TDNN and ARIMA models for later periods. Time was available to perform ***t***-testing for the cases of SAR, TAR, NAR and STAR1. For example, the period 3 prediction errors for TDNN were significantly lower than the period 3 prediction errors for ARIMA in the cases of SAR, TAR and STAR1, but not for the case of NAR. Differences could have been simply inferred by the fact that, for these four models, the ARIMA error tends to rise in later prediction periods, whereas the TDNN error does not. This characteristic is also observed for the NMA case, where the TDNN prediction errors remain relatively constant over the forecast horizon. However, this is not the case for the BL1, BL2, and STAR2 cases. In these cases the TDNN prediction errors generally rise with a longer prediction horizon. It is interesting to note that the ARIMA prediction errors for the cases of NAR and BL1 are fairly constant with increasing horizon and actually improve for the case of NMA. The TDNN models never exhibited improvements after the one period prediction. In general, it is observed that as the prediction horizon increases, the comparative results of ARIMA and TDNN are mixed. TDNN predictive advantage over ARIMA begins to decline. For example, in period 5 only in the cases of SAR, TAR and STAR1 is TDNN better than ARIMA. But, TDNN is substantially better than ARIMA in these three cases, while ARIMA appears to be only slightly better than TDNN in the cases of NMA, BL1, BL2 and STAR2.

TABLE 1. RESULTS FOR ARIMA & TDNN MODELS - ARTIFICIAL DATA SETS

Data Set	Model Type	MAE					MSE				
		pd1	pd2	pd3	pd4	pd5	pd1	pd2	pd3	pd4	pd5
SAR+	ARIMA*	1.06	1.11	1.15	1.16	1.16	1.85	1.97	2.03	2.04	2.05
	TDNN	*0.91*	*0.92*	*0.92*	*0.92*	*0.93*	*1.30*	*1.31*	*1.31*	*1.32*	*1.35*
BL1	ARIMA	1.21	1.19	1.19	1.19	1.19	3.03	2.94	3.00	3.00	3.02
	TDNN	*1.21*	*1.24*	*1.24*	*1.26*	*1.28*	*3.15*	*3.29*	*3.38*	*3.43*	*3.64*
BL2	ARIMA	1.08	1.24	1.23	1.24	1.24	2.04	2.82	2.76	2.81	2.81
	TDNN	*1.04*	*1.17*	*1.24*	*1.26*	*1.25*	*1.93*	*2.40*	*2.70*	*2.82*	*2.74*
NMA	ARIMA	0.99	0.94	0.92	0.92	0.92	1.61	1.44	1.40	1.41	1.41
	TDNN	*0.91*	*0.93*	*0.92*	*0.93*	*0.93*	*1.33*	*1.36*	*1.35*	*1.39*	*1.39*
TAR+	ARIMA*	1.08	1.16	1.21	1.24	1.27	1.84	2.15	2.34	2.47	2.56
	TDNN	*0.86*	*0.86*	*0.87*	*0.87*	*0.87*	*1.17*	*1.19*	*1.20*	*1.21*	*1.21*
NAR	ARIMA	0.81	0.81	0.81	0.80	0.81	1.01	1.01	1.01	1.01	1.01
	TDNN	*0.81*	*0.81*	*0.81*	*0.81*	*0.81*	*1.03*	*1.02*	*1.02*	*1.02*	*1.03*
STAR1+	ARIMA*	0.98	1.01	1.02	1.02	1.02	1.49	1.60	1.63	1.65	1.66
	TDNN	*0.82*	*0.82*	*0.82*	*0.82*	*0.83*	*1.05*	*1.06*	*1.07*	*1.05*	*1.08*
STAR2	ARIMA	0.89	0.90	1.09	1.10	1.18	1.27	1.27	1.94	1.95	2.26
	TDNN	*0.90*	*1.26*	*1.09*	*1.31*	*1.22*	*1.28*	*2.70*	*1.92*	*2.84*	*2.39*

+ $p < .001$, paired ***t***-test comparison of TDNN to ARIMA for all error measures.
* $p < .05$, paired ***t***-test comparison of ARIMA period 1 to period 3 for all error measures.

Selected *t-tests* were run within each model by time period to determine if there was a significant difference in any error variation over the prediction horizon. For example, ***t***-testing of the SAR, TAR, and STAR1 models revealed that the errors for ARIMA were significantly higher in period 3 than in period 1. However, for NAR, there was no significant difference over the prediction

horizon for the ARIMA model. Similarly, there was no difference in error for TDNN over the prediction horizon for the SAR, TAR, NAR or STAR1 models. For BL2 and STAR2 it may be inferred that both TDNN and ARIMA predictions degrade with increasing horizon. For NMA the ARIMA model actually appears to improve in the first 3 periods and then stabilizes, whereas the TDNN model appears to degrade slightly. Finally, for BL1 the ARIMA model appears to improve slightly in the first 2 periods and then stabilizes, whereas the TDNN model appears to degrade with increasing horizon. In general, both ARIMA and TDNN predictions degrade with increasing horizon. While TDNN models tend to degrade somewhat more slowly than ARIMA models, some ARIMA models actually improve initially.

Model Results for Wastewater Treatment Data

From the results of the artificial data sets, we would expect to see TDNN generally perform better than ARIMA for the one period forecast. As the horizon increases, both models will see some degradation and the TDNN advantage over ARIMA will be diminished. We might even see cases where the ARIMA model prediction improves with the longer horizon.

Table 2 reports the results for the nitrogen, phosphorus, biochemical oxygen demand, and suspended solids effluent predictions for all five periods. There is a statistically significant and substantial difference between the ARIMA and TDNN models for the one period prediction for nitrogen. The TDNN errors are about 30% lower than ARIMA for MAE. The TDNN phosphorus one period errors are lower than the ARIMA errors by 29% to 44%. The TDNN modeling approach maintains its predictive accuracy for two and three periods, with no significant increase in errors for *t*-testing. However, the accuracy of the ARIMA model deteriorates rapidly with increasing prediction horizon. From periods one to three, the nitrogen MAE values increase from 0.79 to 1.05 (a 33 % increase). The phosphorus MAE increases from 0.35 to 0.42 (a 20% increase). The TDNN is clearly more accurate than the ARIMA models for multi-period predictions for nitrogen and phosphorus.

TABLE 2. RESULTS FOR ARIMA & TDNN MODELS – REAL DATA SETS

Data Set	Model Type	MAE					MSE				
		pd1	pd2	pd3	pd4	pd5	pd1	pd2	pd3	pd4	pd5
Nitrogen+	ARIMA*	0.79	0.94	1.04	1.11	1.16	1.12	1.56	1.86	2.05	2.21
	TDNN	*0.53*	*0.54*	*0.56*	*0.56*	*0.56*	*0.55*	*0.58*	*0.59*	*0.60*	*0.58*
Phosphorus+	ARIMA*	0.35	0.40	0.42	0.44	.044	0.25	0.33	0.37	0.38	0.38
	TDNN	*0.25*	*0.26*	*0.27*	*0.28*	*0.28*	*0.14*	*0.15*	*0.16*	*0.16*	*0.17*
BOD+	ARIMA	4.54	4.77	4.89	4.90	4.94	36.45	38.75	40.28	39.49	40.12
	TDNN	*4.00*	*4.03*	*4.03*	*4.02*	*4.01*	*29.13*	*29.54*	*29.65*	*29.36*	*29.48*
Suspended Solids^	ARIMA	5.21	5.37	5.47	5.48	5.56	52.44	58.78	59.83	57.76	58.61
	TDNN	*4.92*	*4.94*	*4.92*	*4.92*	*4.92*	*48.27*	*48.31*	*47.85*	*48.04*	*47.76*

+ $p < .001$, paired ***t***-test comparison of TDNN to ARIMA, for MAE and MSE in periods 1, 2 and 3.
^ $p < .005$, paired ***t***-test comparison of TDNN to ARIMA, for MAE and MSE periods 2 and 3.
* $p < .001$, paired ***t***-test comparison of ARIMA, period 1 to period 3 for MAE and MSE.

There is a statistically significant and substantial difference between the ARIMA and TDNN models for the one period prediction for BOD. The TDNN errors are about 12% lower than ARIMA for MAE. The TDNN suspended solids one period errors, although they appear to be lower, were not significantly lower when compared statistically. The differences in MAE of

about 6% are not significant. We observe that TDNN modeling maintains its predictive accuracy for two and three periods, with no significant increase in errors. The TDNN MAE error is essentially unchanged at around 4.00 for BOD and 4.93 for suspended solids. However, the accuracy of the ARIMA model in both the BOD and suspended solids appears to degrade only slightly with increasing prediction horizon. From periods one to three, the BOD MAE values increase from 4.54 to 4.89 (only an 8 % increase). The Suspended Solids MAE increases from 5.21 to 5.47 (only a 5% increase). Although these increases do not appear significant, the TDNN appears more accurate than the ARIMA models for multi-period predictions of this data.

CONCLUDING REMARKS

The main contribution of this study is the recognition that, although powerful, neural networks may not always provide the best solutions or the best model choices when dealing with data characterized by autoregression and nonlinearity.

In our study of eight artificial data sets, neural networks were generally found to perform as good as or better than simpler linear ARIMA models for a one period prediction. However, this advantage was seriously diminished for multi-period forecasting. If one considers the relative simplicity of linear ARIMA as an advantage to using neural networks, then the ARIMA model would be preferred in cases where no difference in performance is found. For the one period forecast the linear ARIMA approach was as good as the TDNN in at least three out of eight cases. For the multi-period forecast, this number rose to five out of eight cases in favor of the linear ARIMA approach in. In this regard, linear ARIMA has an advantage. However, in cases where TDNN was better, it was substantially so. Using measures of BOD, Suspended Solids, Nitrogen and Phosphorus from two real-world wastewater data sets, we found the TDNN outperformed ARIMA for single period and multi-period predictions. To a large degree, the Greenville and Poch data results resemble the SAR, TAR and STAR1 artificial data set results in their characteristics. These were strongly AR models. The presence of MA components in the data may provide different results in wastewater applications. We did not see the same degree of variability in the real world data sets that we saw in the artificial data sets. Since we used only four wastewater variables, we caution that other variables in the system might provide different results. For these commonly measured wastewater variables the TDNN does appear to be superior to the linear ARIMA. However, this cannot be said confidently regarding other less sophisticated neural network approaches. Practitioners are cautioned in particular to consider using the TDNN, as it has been shown to be superior to the MLP neural network model in wastewater applications (Zhu, *et al*., 1998).

The results of the artificial data sets points to at least the possibility that linear ARIMA may be used effectively in wastewater applications. Where multi-period forecasts are useful, such as in watershed quality management involving the prediction of effluent impact several days out, the simpler linear ARIMA approach may be adequate. In some instances it may even be superior.

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A COMPUTERIZED INTERFACE FOR THE LIKERT SCALE PROVIDING NEAR-CONTINUOUS DATA VALUE RESULTS

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ABSTRACT

This paper expands upon the original ideas presented in a previous paper by Russell and Chimi [1] by demonstrating a method by which the Likert Scale is presented to the user in a computerized, interactive interface. The major advantage of the proposed method is the operationalization of Likert scale data with sufficient granularity that results can be treated as continuous quantitative data rather than ordinal qualitative data, as done heretofore. This paper describes the rationale behind the new methodology and includes a demonstration of the new interface. A discussion addressing the advantages of the resulting continuous data is also provided.
Keywords: Likert Scale, statistics, survey research/design, computer interfaces

BACKGROUND

The Likert scale is a psychometric tool used to measure a respondent's attitudes, subjective perception, reaction, or affect on a given topic or matter, developed by Rensis Likert (1903-1981) as part of an extensive body of research that investigated various management styles and, particularly, their effectiveness in achieving conflict resolution. Its objective is to capture, on a linear scale, the respondent's response to a question that requires selection of a response over a fixed range of outcomes. Likert scales "usually consist of two parts, the item part and the evaluative part. The item part is essentially a statement about a certain product, event, or attitude. The evaluative part is a list of response categories ranging from 'strongly agree' to 'strongly disagree'" [2]

The following is an example of a question using a Likert scale approach:

The College's health care plan provides me with the coverage I need.				
Agree Strongly	**Agree Somewhat**	**Neither Agree Nor Disagree**	**Disagree Somewhat**	**Disagree Strongly**
☐	☐	☐	☐	☐

REASON FOR COMPUTERIZED SCALE

There are several problems with the Likert scale as typically used that provide the impetus for the computerized interface described in this paper. First, it provides no mechanism for the subject to register the fact that s/he does not have the necessary

information to answer the question meaningfully. There is the center position of the scale, but that actually registers as having information but being indifferent. Second, the scale provides categorical or qualitative results. The data values thus obtained have no real numerical meaning, beyond perhaps a certain implied ordinality. This makes those results less useful in a statistical sense, where quantitative values allow for richer veins of analysis, particularly if those values are continuous as opposed to discrete. The modification to the Likert scale proposed in the earlier paper and demonstrated within this proposed paper squarely addresses these issues by providing a separate checkbox for the person who cannot meaningfully answer the question, and by collapsing the categories into one simple linear, continuous scale. We demonstrate the computerized interface below.

EXAMPLE OF COMPUTERIZED SCALE

Figure 1 below shows a representation of a web interface for the new Likert Scale modification. Shown are the question, a bit of direction for the subject, the actual scale with moving slider, radio buttons for the subject to check should she not wish to use the slider, and Submit and Reset buttons. Below the scale, in the center, is a number that represents the actual data value to be recorded. This value is shown here just for presentation purposes in this paper and the presentation that will derive from it; it would not normally appear to the actual subject of a research study unless desired by the researcher.

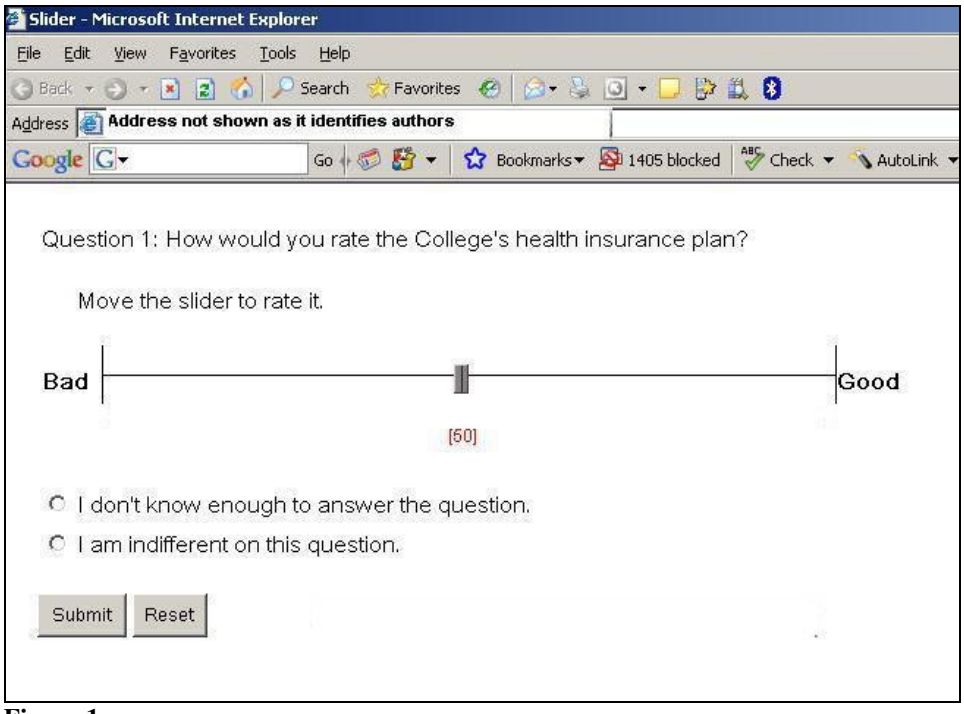

Figure 1

In Figure 2 below, the subject has moved the slider to indicate her preference along the scale. Notice that the data point has changed to 78.2. This is the value that would be recorded were the subject to then hit the Submit button.

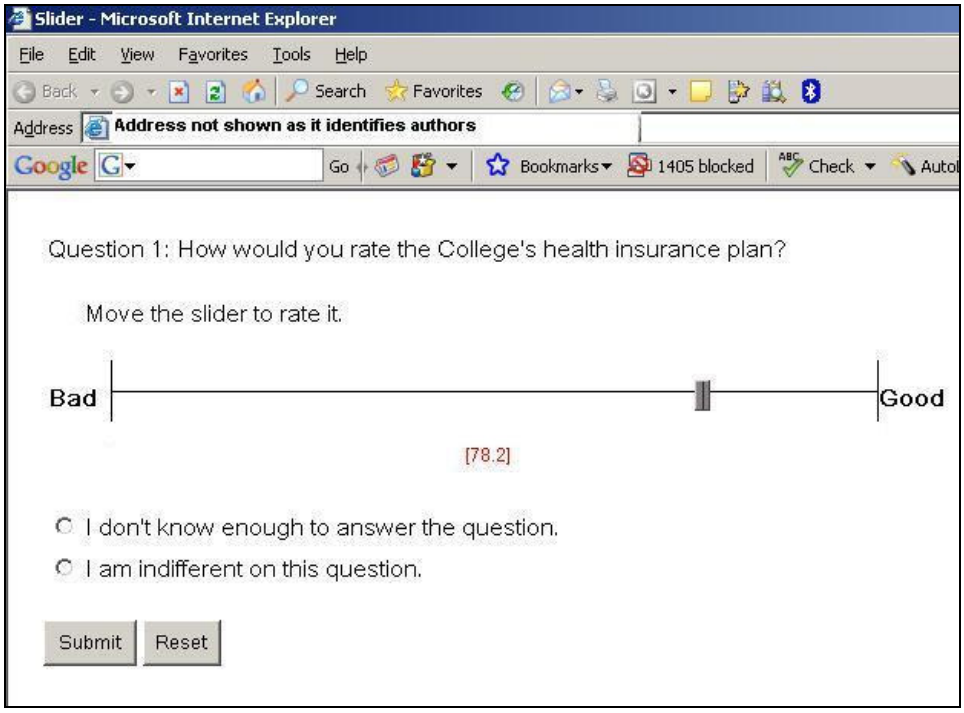

Figure 2

ADVANTAGES OF THE PROPOSED METHOD

The traditional Likert scale produces qualitative data, namely, the count of respondents choosing each of the choices available. This is its first major flaw: qualitative data allow for a far more limited range of analysis tools than do quantitative data. There is no implication that the values are scalar (for example, in a traditional five-response Likert scale, are the degrees of agreement or disagreement of equal value?). Second, the traditional Likert scale does not explicitly provide for those respondents who lack sufficient knowledge to answer the question and those who possess sufficient knowledge, but who are indifferent in their response. The lack of a way to capture this undoubtedly skews the response toward the middle value, particularly in those cases in which a response is mandatory.

The proposed technique addresses both points. As noted above, the subject is provided a large number of potential responses, which are captured by the degree to which s/he moves the scale left or right, that is, closer to or further away from the semantic differential anchors. While the user might see 100 points on the scale, in reality the response is measured with more precision (in the example above, to the first decimal value). As a result, the data captured is not only quantitative, it is continuous (or, at least, captured precisely enough to be treated as continuous; the actual precision would be limited by the resolution of the computer screen employed) . Further, we can capture the

two special cases of respondents lacking sufficient knowledge to answer and those who are indifferent.
Quantitative continuous data allow for a far richer array of statistical analysis tools, of which two are suggested here. [3] First, correlation is not possible with qualitative data unless one assigns some arbitrary value to each response, an artifact which would call into question the resulting correlation coefficient. In the example shown, however, continuous data results, allowing correlation analysis to proceed. Second, *t*-tests comparing two different questions are possible. This is a great improvement over the contingency tables available when using qualitative data, as it permits the more powerful *t*-test to be used instead of an χ^2 test of independence or (if one of the responses is quantitative) the ANOVA test.

CONCLUSION

This paper has presented a refinement to the Likert Scale using a computerized interface to collect continuous data values for each question and handling the problem of people who do not know enough to answer the questions but have no way to register that fact using the traditional scale. The resulting data allow the researcher to employ the more robust statistical analysis methods available for continuous quantitative data. Example screens of the new interface were provided.

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Voting Machine Impact on US Elections

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Abstract

Voting machines used in US national elections have become a source of scrutiny since the year 2000. A number of studies were done based on the 2000 and 2004 national elections, focusing on the accuracy of the voting machines used and their susceptibility to tampering after the votes were cast and polls were closed [1] [2]. Such studies examined the difference between exit polling and the actual vote results in various precincts of particularly decisive states. This paper will focus on the recent changes in voting machines and their impact on elections and exit polling.

Keywords: Voting Machines, Elections, Exit Poll.

Introduction

The US presidential race in 2000 was so close as to require a vote recount in certain precincts in Florida. During the recount process, the vote process and the accuracy of the voting machines came into question. The most significant controversy was the Florida recount, involving the infamous "hanging chads" that were caused by punch card voting machines.

More recently, Ohio was the main focus of the 2004 presidential election. In that case, there were claims of voting machine inaccuracies. One concern was that the machines simply made errors in counting votes. The more cynical concern involved machine tampering in favor of a particular candidate. Many states have taken a hard look at the voting machines used in their precincts and have made changes over the past several years.

On the day of the election in 2002, the exit poll data was apparently in error and discarded. This data would normally be supplied to the major news agencies for reporting, its absence prevented confident projections to be made during the evening of the election. Exit poll data from the 2002 mid-term elections has not been made available.

This paper will focus on developing changes to the national US voting system. Despite the success of the democrats in 2006, there remain questions about voting results,

specifically in terms of tampering with votes in order to change the outcome of an election. This concern comes mainly from groups associated with the Democratic Party, and others who want to insure independent verification of results.

Voting Machines / Exit Polls

Figure 1 below [4] shows the shift toward electronic voting methodology in recent elections. Note that almost 90% of all votes are now cast by either optical (read by a scanner) or electronic (punch screen) means.

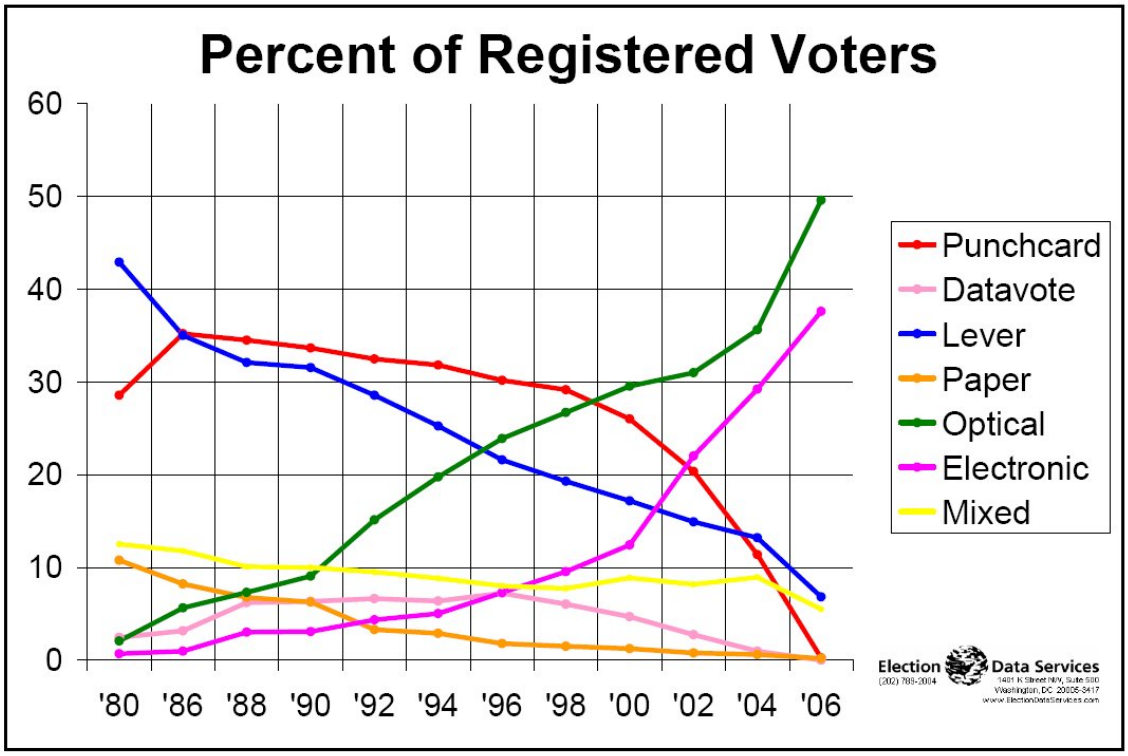

Figure 1

There have been a number of complaints during the past two elections (2004 and 2006) of computer problems, particularly related to electronic voting [1] [7]. Electronic voting lacks an appropriate paper trail in the case of a contested vote within a precinct. Even the optical vote counts utilize computer counting and errors can easily go undetected.

Recent exit polling problems compound the issues surrounding changes in voting machines. Consider that the presidential election of 2000 was an embarrassment to a number of news organizations as they called a victory for Al Gore in Florida when it turned out he actually lost the state to George Bush. This error then magnified suspicion about the "hanging chads" in some of the punchcard ballots. Absentee ballots also became an issue in Florida at that time.

In 2002, exit poll data was considered in error and discarded. This obviously had an impact on making early election night determinations for all of the various mid-election races. Missing data left statistical analysts void of important data for studying congressional and gubernatorial contests. This inability to verify vote counts with at least one exit poll leaves the voting machine results unchecked.

Then, in 2004 there were more claims of problems with various voting systems and the major news organizations became shy about calling states for either of the presidential candidates. Among the issues already raised from prior elections, we can now add the wide variety of voting systems among the states as a cause of concern to many people.

Finally, the 2006 mid-term election was not as controversial as the other recent elections had been. Still, there were a number of voter complaints involving the excessively long wait at the polls. Also, a look at the 7pm and even 11pm exit polls in comparison with the actual vote count revealed, as it did in 2004, that the exit polls were favoring the democratic candidates about 6% more than was reflected in the actual vote [5].

Cause for Concern

Insuring a fair, verifiable, and transparent national voting system is at risk for the following reasons:

- Voting machines have some degree of risk for tampering and/or error [6] [8] [9].

- It is very difficult to check the validity of voting results without the use of thorough exit polling. Analysts may try and use Party Registration numbers as a check for the validity of the results, however, this is not easy since states have different registration rules (some allow same day registration for example) and the number of Independent or other party affiliations makes this analysis difficult.

- Exit poll data is maintained by EDS (Election Data Services). The major source of exit poll analysis for use by the major networks is performed by Edison Media Research and Mitofsky International. There are no other major sources of exit poll data to use as an independent check on the results.

- Surprisingly, the national exit poll data does not contain useful location demographic information on the survey participants. This means that proportions of voters cannot be tied to a particular county or precinct. Thus, we are unable to compare voting system results with exit poll results. Some states (such as Ohio) don't allow information such as this to be released.

- Finally, exit poll results by state in 2000 and 2004 that were released by the Edison / Mitofsky Research group was modified to match the actual results almost exactly for every state. The explanation, seemingly reasonable, is that each exit poll survey should be weighted correctly based on the demographics of the actual voters (thus attempting to create an excellent stratified sample). Therefore, exit

polls could not be finalized until the end of the evening. They claim that this is what made earlier predictions imprecise.

Based on the points described above, it is very difficult to argue for or against the validity of vote results from any particular voting precinct, county, or even state. A cynic would suggest that because our voting system is so secretive (perhaps inadvertently), most likely there is tampering that is occurring. The one thing that can be said with much certainty is that the people running our government could make our system of voting far more transparent and verifiable.

Results

There are many interesting statistical studies that could be performed with regard to voting machines, actual election results, and exit poll results. Unfortunately, many of these ideas are stifled by a combination of lack of available data, manipulated data, and other typical election obstacles (such as more than 2 candidates, survey bias, and candidates that have some special appeal). Two results that are presented here include:

- Based on Table 1 below [9], the relationship between E-voting and the difference between the 11pm exit poll and actual vote percentage for George Bush was tested. A simple linear regression was performed and did not show any significant relationship between the increased use of electronic voting and the size of the vote discrepancy.

  Note that the 1am exit poll gives percentages of Bush votes very close to the actual outcome. There was a negative correlation between E-voting and the voting discrepancy (mostly negative) as of 11pm. This correlation was not statistically significant (p-value of .13), but was in the direction that a concerned citizen might fear, namely, that Bush did a lot of catching up at the end of the night in states that had more electronic voting machines (less traceable).

  Similar results were found with regard to the year 2000 data with very little correlation (p-value = .76).

Table 1

State	Bush, 11 pm (CST) Exit Poll	"Actual Vote"	Bush, 1 am Exit Poll	2004 E-voting
AL	58	63	63	14%
AR	53.5	54	54	5%
AZ	53	55	55	0%
CA	43.5	44	45	25%
CO	50	53	52	7%
CT	41	44	44.5	0%
DC	8.5	9	9.5	0%
DE	40	46	46	100%

FL	50	52	51.5	54%
GA	56	59	59	100%
HI	46.5	45	46.5	0%
IA	48.5	50	50.5	10%
ID	66	68	68.5	0%
IL	42.5	44	44.5	0%
IN	58.5	60	59.5	49%
KS	64.5	63	63	36%
KY	58.5	60	59.5	81%
LA	55	57	57	55%
MA	33	37	37	0%
ME	44.5	45	45	0%
MI	46.5	48	48	0%
MN	44.5	48	47	0%
MO	52	54	53	0%
MS	57	60	59	15%
MT	58	59	57	0%
NC	52	56	57	43%
ND	64.5	63	63	0%
NE	62.5	67	66	0%
NH	44.5	49	49	0%
NJ	43	46	46	73%
NM	47.5	50	50	0%
NV	48	51	50.5	100%
NY	35.5	40	41	0%
OH	48	51	51	50%
OK	65	66	65.5	0%
OR	48	47	48	0%
RI	35	39	39	0%
SC	53	58	59	86%
SD	61	60	60	0%
TN	58	57	58	73%
TX	62	61	61	1%
UT	68	71	70	0%
VA	52	54	54	6%
VT	33.5	39	39	0%
WA	44	46	46	3%
WI	49	49	49	0%
WV	54	56	55.5	9%
WY	65.5	69	68.5	2%

- A similar test was performed in the state of Ohio for the 2006 gubernatorial race. In this case, the exit polls could not be tied to particular counties or precincts and therefore a comparative analysis to voting machines could not be performed. The difference between Republican Party registrations and actual vote percentage for the republican candidate Kenneth Blackwell was tested against the E-voting indicator variable by county [3].

A simple Wilcoxyn non-parametric test was used and showed high actual vote percentages for the E-voting group with a statistically significant p-value of .04. There is some concern, however, of having some dependence between observations because of Party registration rules in Ohio. There needs to be more investigation of these rules prior to pursuing this type of analysis.

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A COMPARISON OF LOGISTIC REGRESSION, NEURAL NETWORKS, AND CLASSIFICATION TREES IN A STUDY TO PREDICT SUCCESS OF ACTUARIAL STUDENTS

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ABSTRACT

In a previous paper, two of the authors conducted a study designed to predict the successful completion of students enrolled in an actuarial program. They used logistic regression to determine the probability of an actuarial student graduating in the major or dropping out. The present paper will compare the results of this study with those obtained by re-examining the data using neural networks and classification trees, techniques from the SPSS Data Mining package which can provide a prediction of the dependent variable for all cases in the data set including those with missing values.
Keywords: Logistic Regression, Data Mining, Missing Values

INTRODUCTION

Logistic regression is the statistical technique commonly used for prediction of a dichotomous dependent random variable. It therefore is an excellent choice for the prediction of success in a course or program. In a previous paper, two of the authors conducted a study which resulted in an article entitled, "Academic Attributes of College Freshmen That Lead to Success in Actuarial Studies in a Business College" [1]. As part of the research for that article, the authors obtained a logistic regression model to determine the probability of an entering actuarial student actually graduating as an actuarial concentrator or dropping out of the concentration along the way. The present paper will compare the results of this study with the results obtained by re-examining the data using neural networks and classification trees. These two techniques are part of the SPSS Data Mining package and have the advantage of utilizing all of the available data to predict the dependent variable for all cases in the data set including those with missing values.

PREVIOUS RESULTS

The data used for the Actuarial study cited above was obtained from 201 Bryant University graduating students who had begun their college careers as freshman actuarial majors in the years 1995-2001. Of these students, 42% graduated as actuarial concentrators (actuarial graduates). The remaining 58% dropped out of the concentration (actuarial dropouts) at a variety of points in their college careers.

Since the goal of this research was to measure success in the program by whether or not the student graduated in the major, the dependent variable was defined as a dichotomous variable (0 = actuarial drop out, 1 = actuarial graduate). A previous study which concentrated on actuarial graduates, found that among undergraduate actuarial graduates, math SAT scores (MSAT), verbal SAT scores (VSAT), percentile rank in high school graduating class (RANK), and percentage score on a college mathematics placement exam (TEST) had some relevance to forecasting the students' grade point averages in their concentration [2]. These four academic variables, which were all available prior to the students starting in the program, were therefore selected to be used as independent variables to construct a logistic regression model providing the probability of a given student becoming either an actuarial graduate or an actuarial dropout.

A logistic regression was run with gender as an independent variable in addition to the four academic variables. A test of the full model with all five predictors was statistically reliable with a chi-square value of 50.574 ($df = 8$, $p < .001$). In addition, the Hosmer and Lemeshow Test statistic yielded a chi-square of 6.072 ($df = 8$, $p = .639$) indicating that the model's estimates fit the data at an acceptable level. The logistic regression showed that 72.1% of the students predicted to be actuarial graduates were actuarial graduates and that 76.7% of the students predicted to be actuarial dropouts were, in fact, dropouts. Overall, the logistic regression model accurately classified 74.7% of the sample of actuarial graduates and dropouts to their correct category. It is interesting to note that three of the four academic variables were significant in the logistic regression model: TEST ($p < .009$), MSAT ($p < .0041$), and RANK ($p < .016$), whereas neither GENDER ($p = .529$) nor VSAT ($p = .514$) were significant.

As a result of the requirements of logistic regression, the number of cases with missing values that were actually excluded from the analysis included approximately 15% of the total number of students involved in the study. This is a serious drawback to using this procedure for prediction since although 74.7% of the students who were able to be classified were classified correctly, the procedure was not able to predict results for 15% of the students. This can be a serious problem in academic predictions since often class rank is not available and some students have ACT scores instead of SAT scores. Also, although the college Math placement test is required and is currently available in online format, it is often difficult to get all students to take the test in a timely fashion. In other applications, it is just as difficult to avoid missing values and yet it would be very helpful to be able to make predictions for all observations in the data set.

Consequently, although the overall classification rate obtained by the logistic regression was quite good, we wondered whether we could improve accuracy and at the same time minimize missing observations, thereby also possibly reducing any bias, by utilizing techniques from the area of data mining, namely, neural networks, and classification trees. These techniques are less affected by missing values. We also hoped to be able with these techniques to predict success for all members of the entering class.

We decided, therefore, to utilize the same data and the alternative procedures to determine correct placement of students as well as classification accuracy. SPSS Clementine will be the data mining software of choice. The original study was completed using SPSS. As mentioned, results will be compared. Advantages and disadvantages of the various approaches will also be contrasted.

DATA MINING RESULTS

The data will now be re-analyzed using the SPSS Clementine Data Mining software. We will look at the output obtained from the following procedures: Logistic Regression (to compare with the traditional SPSS logistic regression), Neural Networks, and three Decision Tree methods (C5.0, CART, and CHAID). The procedures were run, first omitting missing values as was done in the previous study, and then including the missing values. Procedures are run in Clementine through the use of streams. Figure 1 depicts the stream used to execute the five procedures in our study. It starts with a source node to read the data, a type node to assign variable types, the procedures to run (the 5 pentagons), the results (gold nuggets), and the attached analysis nodes to determine classification accuracy. This stream is easily constructed by grabbing the nodes from the toolbar at the bottom of the screen and connecting these nodes with arrows in a sequential fashion.

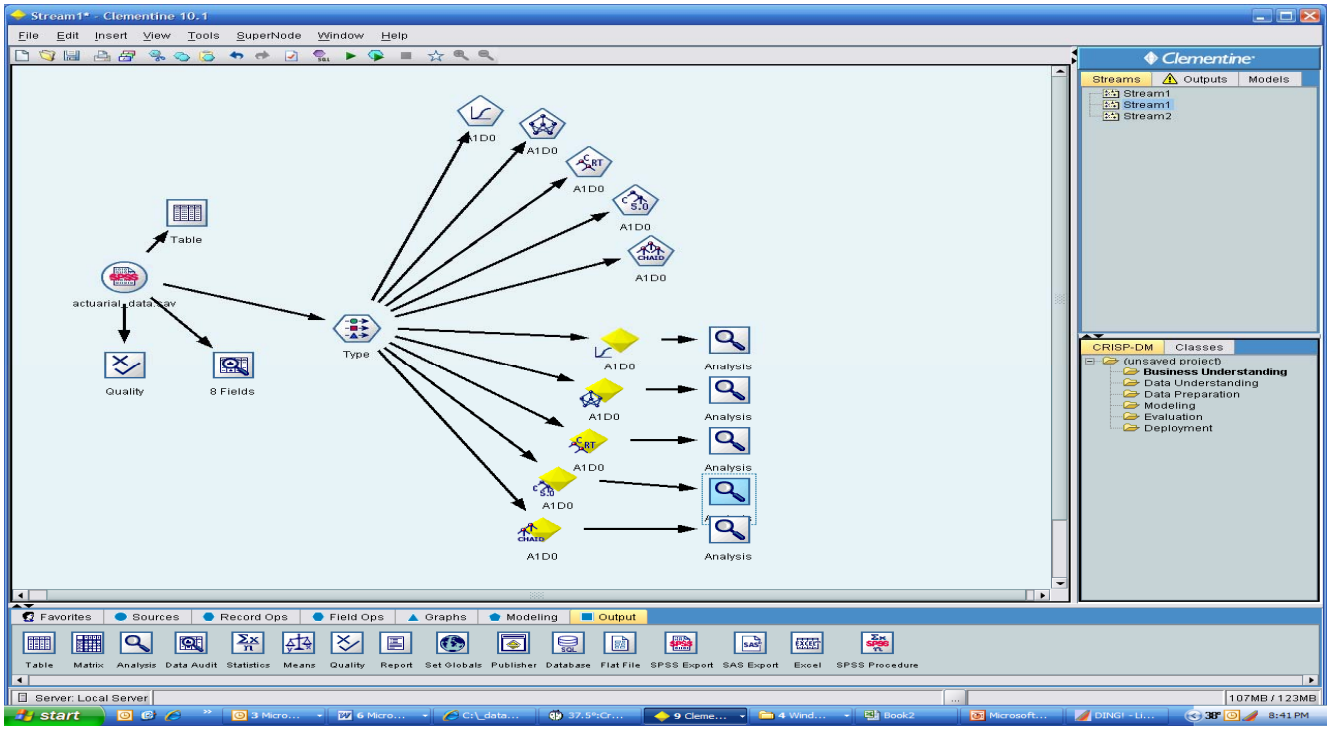

Figure 1: Clementine Stream

Logistic Regression

A stream in Clementine was created to read the data, assign independent and dependent variables as defined in the previous research study, run a logistic regression and determine the classification accuracy. This was done with the missing records removed rather then the full data set in order to be comparable to the previous study. This procedure yielded similar results to the previous study. That is it predicted with 74.21% accuracy for those students who had complete records. Also, the significant variables were again TEST, MSAT, and RANK. It is interesting to note that the logistic regression results are clearly less accurate when the missing values are included. The model only classified 60.7% of all students correctly. This is to be expected since when the missing values are included, the same number of observations are correctly classified

but this is a smaller percentage since we are including all cases, and so this is a more accurate measure of the classification accuracy obtained with this procedure.

Neural Network

A Neural Network, according to the SPSS Clementine Manual is "basically a simplified model of the way the human brain processes information. It works by simulating a large number of interconnected simple processing units that resemble abstract versions of neurons. The processing units are arranged in layers. There are typically three parts in a neural network: an **input layer**, with units representing the input fields; one or more **hidden layers**; and an **output layer**, with a unit or units representing the output field(s). The units are connected with varying connection strengths (or **weights**). Input data are presented to the first layer, and values are propagated from each neuron to every neuron in the next layer. Eventually, a result is delivered from the output layer. The network learns by examining individual records, generating a prediction for each record, and making adjustments to the weights whenever it makes an incorrect prediction. This process is repeated many times, and the network continues to improve its predictions until one or more of the stopping criteria have been met. Initially, all weights are random, and the answers that come out of the net are probably nonsensical. The network learns through **training**. Examples for which the output is known are repeatedly presented to the network, and the answers it gives are compared to the known outcomes. Information from this comparison is passed back through the network, gradually changing the weights. As training progresses, the network becomes increasingly accurate in replicating the known outcomes. Once trained, the network can be applied to future cases where the outcome is unknown."[3]

When the Neural Network was run on the data with the cases with missing values removed, the resulting network classification accuracy was 72.96% with the input variables resulting in the following measures of relative importance: MSAT (0.583587), TEST (0.478069), RANK (0.374098), VSAT (0.199113), and GENDER (0.00773338). Thus, these results were again similar to the original logistic regression results. When a neural network was obtained with the complete data set, the results were very similar. The resulting network classification accuracy was 72.14% with the input variables resulting in the following measures of relative importance: MSAT (0.418433), TEST (0.199338), RANK (0.344853), VSAT (0.041625), and GENDER (0.00326346).

Decision Trees

The Clementine Manual defines the C5.0 model thus: "A C5.0 model works by splitting the sample based on the field that provides the maximum **information gain**. Each sub sample defined by the first split is then split again, usually based on a different field, and the process repeats until the sub samples cannot be split any further. Finally, the lowest-level splits are reexamined, and those that do not contribute significantly to the value of the model are removed or **pruned**."

The CART (Classification and Regression Tree node), as defined in the manual: "is a tree-based classification and prediction method. Similar to C5.0, this method uses recursive partitioning to split the training records into segments with similar output field values. C&R Tree starts by examining the input fields to find the best split measured by the reduction in an impurity index that results from the split. The split defines two subgroups, each of which is subsequently split

into two more subgroups, and so on, until one of the stopping criteria is triggered. All splits are binary (only two subgroups)."

Finally CHAID (Chi-squared Automatic Interaction Detection) is "a classification method for building decision trees by using chi-square statistics to identify optimal splits. CHAID first examines the cross tabulations between each of the predictor variables and the outcome and tests for significance using a chi-square independence test. If more than one of these relations is statistically significant, CHAID will select the predictor that is the most significant (smallest *p* value). If a predictor has more than two categories, these are compared, and categories that show no differences in the outcome are collapsed together. This is done by successively joining the pair of categories showing the least significant difference. This category-merging process stops when all remaining categories differ at the specified testing level. For set predictors, any categories can be merged; for an ordinal set, only contiguous categories can be merged." [3]

The C5.0 Decision Tree with missing values removed, yielded much better results than the logistic regression (88.05% accuracy) but with a rather complicated rule set. The CART procedure resulted in 86.79% accuracy and CHAID resulted in 78.6% accuracy with missing values removed.

Now when the Decision trees were run with the complete data set, the results were as follows: The C5.0 yielded 81.59% accuracy, CART had 85.07% prediction accuracy and CHAID yielded 75.62% accuracy. Even with drastically pruning the tree, and using only two rules, the C5.0 classification with missing values included with an accuracy rate of 73.63% does as well as the logistic regression with missing values removed. CART with a pruned tree produced 76.12% accuracy.

COMPARISON OF RESULTS

The results for all procedures are presented in Table 1 for the models run by removing cases with missing data and in table 2 for models run with all cases included. It can be seen that when the cases with missing data are removed, the Clementine Logistic Regression and the Neural Network do not significantly improve the accuracy of prediction over the original study but that the Decision trees do improve the accuracy significantly.

Procedure	Classification Accuracy
Logistic Regression	74.21%
Neural Network	72.96%
C5.0	88.05%
CART	86.79%
CHAID	78.62%

Table 1: Summary of Classification Accuracy (Missing Data Removed)

As can be seen in Table 2, when the data is run with all cases included, the Logistic regression has less accuracy, and the Neural Network is about the same but the decision trees even when pruned do as well or better than the traditional logistic regression.

Procedure	Classification Accuracy
Logistic Regression	60.7%
Neural Network	72.14%
C5.0	81.59%
C5.0 Pruned	73.63%
CART	85.07%
CART Pruned	76.12%
CHAID	75.62%

Table 2: Summary of Classification Accuracy (Including Missing Data)

It should also be mentioned that with all of the Clementine models the independent variables that had the greatest influence on the success of the student were Math SAT, Placement Test Score, and Rank in class with gender and verbal SAT the least influential. This result is comparable with the original study.

CONCLUSION

Although logistic regression is a popular method for predicting a categorical variable, alternative techniques exist and many are included in data mining packages. While logistic regression will ignore any cases with missing data in the predictor variables, neural networks and decision trees can include all data with very promising results. For the example included in this paper, the Decision Trees in particular provided increased accuracy of prediction even when including cases with missing data. This is certainly an improvement since in cases of placement it is important to have a prediction for all subjects including those with missing values. Obviously, this was a very limited example and an extensive simulation would need to be conducted in order to make generalizations

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Lost Sales

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Abstract *The typical way service level is measured in industry is the demand filled over total demand. Unfilled demand becomes a backorder or lost sales. Lost sales demand is often not known or measured by the management. This paper shows how to estimate the lost sales demand and also shows how to measure an effective service level*

Introduction

Most companies are unaware of the amount of lost sales that they incur and have no way to measure this important demand. This paper formulates a lost sales model and shows how to measure this demand and also how to limit and control the lost sales. The basic formulation of this paper comes from [7] where the relationship between demands, service levels, backorders and lost sales are defined.

One of the key measures that management uses to gauge their inventory performance is by way of the service level. A common way to measure the service level (sl) is the ratio of (demand filled) over the (recorded demand). This measure is also referred as the percent fill. Generally a service level of .95 or higher is sought by the management. The reported measure of service level is often computed over all or a portion of the parts in the inventory and for a particular time period as one week, one month or one year.

A fault in the above measure of the service level is that sometimes not all of the demand on the items are known or are recorded. This happens when a customer has need for an item and the item is not available in stock and the sale is lost. Here the demand is not satisfied and this unfilled demand becomes either a backorder or a lost sale. It is a backorder when the customer will wait for the stock to be replenished whereby the demand is subsequently filled. It is a lost sale when the customer does not wait for the stock to be replenished and drops the demand. In this latter case, the demand is mostly not recorded.

References [1,2,4,5,6] show how to set the safety stock to yield a desired service level. The difficulty is that the definition on the service level is not always the same from company to company. References [2,6] give methods on how to set the safety stock when the criteria is to minimize the lost sales or the backorders.

The demand model

Consider the demands associated with a stocking facility that are obtained from the total demands for a fixed period of time (here called a review time) and the total demands over a category of items. Often the only demands known are those that are recorded as sales. But the total of demands could be classified in more detail. This model uses such categories as filled demands, unfilled demands, backorder demands, lost sales demands and effective demands. This demand model identifies the category of demands and shows how they are related and how they can be measured.

The demand model also describes the service level (demand filled over total demand) and how it is related to the demand categories in the model. Some stocking facilities measure and know exactly what their service level is over all the items and over a review time. Other facilities do not measure or know this measure. In the typical industrial systems to control the inventory, the service level is set and the safety stock needed is determined accordingly. Some companies measure and know the service level they are achieving and some do not. The FIRM industrial system [3] is very accommodating since with each run, it allows the management to set the service level to achieve, measures the current service level and also measures the lost sales of the stocking facility.

Below is a review on the various category of demands, the service level and also on the percent of unfilled demands that become backorders.

Demand categories The recorded demand (dr) is the aggregate of customer demands that is ultimately filled by a stocking facility over a period of time (year, month) and for a category of items (parts, products). The quantity could be stated in units of pieces, dollars or lines. This demand is from the customer orders that comes in and are filled immediately (df) and also from the customer orders that are not filled immediately and are placed on backorder and are filled ultimately (dbo). Note another category of demand is when the customer orders are not filled immediately and the customers cancel the order. This latter demand is here called the lost sales demand (dls). In this model, the total demand recorded is derived from dr = (df + dbo) and does not include the lost sales demand. In most situations, the lost sales demands (dls) are not recorded or known. All the demands noted here are in the same units (pieces, dollars or lines).

Service level The service level (sl) is a measure of the portion of the demands that are immediately filled from the stock available. This measure is an aggregate over all the items in the category and over the time period under review. This is obtained by sl = (df /dr). Notice the lost sales demand is not included here since this demand is really not known. In essence, dr is not the total demand, it is only the demand that is known and for convenience here, it is called the total demand recorded. In the event the lost sales demand (dls) was known, the real total demand would be known. For convenience here, this total demand is denoted as the total effective demand (de). This would be de = (df + dbo + dls). In this paper, the service level associated with the effective demand is called the effective service level and is computed by sle = (df/de).

Backorder portion of the unfilled demands This factor is really not known by the management and is like a probability with a value falling between zero and one. Although the exact value of this factor is not known, most managements can provide fairly good estimates. When a customer order comes in and the stock is not available to fill the order, the customer order is unfilled demand (du) and the customer order becomes either a backorder or a lost sales. So, pbo is the portion of the unfilled demand that becomes a backorder. This is pbo = (dbo/du). The portion of the unfilled demand that becomes a lost sales thereby is derived from pls = (dls/du). Note where pbo + pls = 1.

So using only the data typically known for a stocking facility (dr, sl, pbo), the other measures described above can be determined. This is in the following way.

df = sl × dr	= demand filled (immediately)
pls = 1 - pbo	= portion of unfilled demand that becomes a lost sale
dbo = dr - df	= backorder demand
dls = dbo × (pls / pbo)	= lost sales demand
du = dbo + dls	= unfilled demand
de = df + du	= effective (total) demand
sle = df / de	= effective service level

Example 1 Consider a location where the annual sales is $1,000,000 and the service level is measured as 0.90. The management estimates that 50% of unfilled demands are lost and 50% go on backorder and is ultimately filled. With the notation of this paper we have:

dr = 1,000,000	= demand recorded
sl = 0.90	= service level
pbo = 0.50	= portion of unfilled demand that becomes a backorder

Now using the relations given above, the following measures are computed:

df = sl × dr	= 900,000	= demand filled immediately
pls = 1 - pbo	= 0.50	= portion of unfilled demand that becomes a lost sale

dbo = dr - df	= 100,000	= backorder demand
dls = dbo × (pls / pbo)	= 100,000	= lost sales demand
du = dbo + dls	= 200,000	= unfilled demand
de = df + du	= 1,100,000	= effective total demand
sle = df / de	= 0.818	= effective service level

Hence, when the service level is set to sl = 0.90, the annual lost sales is $100,000 and the effective service level is 0.818.

The lost sales model Using the structure from the model presented above, it is possible for the management to specify a limit on the lost sales demand (dls) and then find the service level (sl) that is needed to accomplish this goal.

In reviewing the above demand model, the data that remains constant regardless of the setting of the service level (sl) are the effective demand (de) and the portion of backorders (pbo) from unfilled demand.. First note the effective demand is de = (df + du) and although df and du will change with sl, the sum (de) remains the same. Hence, de is a constant. Further, the portion of backorders and the portion of lost sales from unfilled demands (pbo, pls) are not related to the service level. So now (de, pbo, pls) are constants and are included as data available to carryon the lost sales model. A list of the known data are below:

dls	= (specified) lost sales demand
de	= effective demand
pbo	= portion of backorders from unfilled demands
pls	= portion of lost sales from unfilled demands

Continuing with the model, the following relations lead to finding the service level (sl) needed to achieve the goal specified on lost sales demand (dls).

dbo = dls × pbo/pls	= backorder demand
du = dbo + dls	= unfilled demand
df = de - du	= filled demand
sle = df / de	= effective service level
dr = df + dbo	= recorded demand
sl = df / dr	= service level

Example 2 Continuing with the earlier example, de = 1,100,000, pbo = 0.50, and pls = 0.50 are known. Suppose management also sets a goal on the lost sales demand to dls = 40,000 (for 50,000). So now the computations to find the service level (sl) are the following:

dbo = dls × pbo/pls	= 40,000	= backorder demand
du = dbo + dls	= 80,000	= unfilled demand
df = de - du	= 1,020,000	= filled demand
sle = df / de	= 0.927	= effective service level
dr = df + dbo	= 1,060,000	= recorded demand
sl = df / dr	= 0.962	= service level

The results show when the goal on lost sales demand is set to dls = 40,000, the service level needed to achieve this goal becomes sl = 0.962. Further, the effective service level is sle = 0.927.

Summary

This paper concerns the demands, service level and lost sales that are incurred in an inventory stocking facility over a category of items (parts, products). The demands are classified as recorded demands, unfilled demands, backorder demands, lost sales demands and effective demands. The service level and the effective service level are described and methods to measure are shown. A way to measure the lost sales demand is given and a method to control this demand is shown.

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AN INVENTORY MODEL WITH BACKORDERS AND LOST SALES FOR A DECENTRALIZED MULTI-ECHELON SUPPLY CHAIN

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ABSTRACT

The purpose of this paper is to recast the inventory model to be more relevant in today's situation incorporating backorders and lost sales faced by upstream stages of a decentralized multi-echelon supply chain. In our model, the backorder cost rate per unit time is an increasing linear function of shortage time, which is practically reasonable for a party responsible for its downstream's shortage cost due to his backorders. Our model suggests a finite optimal inventory cycle and shortage period in which the optimal strategy is to control the shortage time per cycle.

Keywords: Inventory control, Shortage cost, Multi-echelon supply chain

INTRODUCTION

The essence of inventory control is to balance the tradeoffs of inventory carrying, ordering and shortage costs. Holding larger inventory results in higher carrying cost, but reduces the cost of ordering and backorders/lost sales. As the implementation of JIT practice becomes more and more widespread, each echelon in a supply chain tends to hold lower inventories, and may even incur deliberate shortages if it is cost efficient. Thus, the whole supply chain is now made more vulnerable to lost sales and/or backorders. Carefully designed inventory policies are critical for all parties involved in a supply chain and each party is responsible for downstream shortages if it is due to its own backlogs. The purpose of this paper is to recast the inventory model to be more relevant in today's situation incorporating backorders and lost sales faced by upstream stages of the supply chain. We propose a new structure of backorder costing and show that in our scenario this is more realistic and superior to the existing cost structures, because it provides a model to both derive cost efficiency from scheduling shortages and protect the supply chain and eventual customers from infinite delivery delay.

Three types of backorder cost are commonly adopted in the existing inventory literature. One of these is constant for each unit backlogged, without differentiating the fulfillment waiting time. Such a cost is one dimensional in the form $\$/unit$ (Hadley and Whitin [4], Chen and Zheng [2]). Another type of cost structure is proportional

to the shortage time, regardless of the backorders volume. It also has a single dimension in the form $\$/time\ unit$. Peterson and Silver [6] has discussed this shortage cost structure. The final form of backlog cost accumulates at a constant rate proportional to both the backorder volume and backlog duration. In other words, the cost coefficient is constant in a two dimensions $\$/unit/time\ unit$. This cost structure is adopted in [5] and [3].

We consider the situation when a sequential system of stages in a supply chain creates a chain reaction in which the backordering penalty cost continues to be transmitted to the upstream stages. With the passage of time, more downstream stages are involved in a shortage, which results in higher per unit time shortage cost throughout the supply chain. Because this cost is due to the backorders at an upstream stage, the resulting penalty cost is likely to be allocated to this stage. Thus, for an upstream stage, it would be more realistic to assume that the cost of backlogging per unit time increases as the order's waiting time increases. In other words, we agree with the dominant literature in that the total backorder cost accumulates both in terms of volume and time, and we propose that the cost per unit per unit time $[\$/unit/time\ unit]$ is not constant, but increases with the duration of the shortage. In this paper, we assume this per unit per unit time backorder cost is linear in the form $[C_0+b(t-t_0)]/unit/time\ unit$, where C_0 is the fixed cost part of unit backorder cost, $b(t-t_0)$ is the variable cost of unit backorder cost, in which $t-t_0$ is the waiting time so far (t is current time and t_0 is the order placement time). b is a positive cost coefficient that determines the increasing rate of the backorder cost per unit per unit time. It generally dictates how fast the downstream units are involved into the shortage and is a measure of the supply chain's shortage vulnerability. We call it Unit Backorder cost Increasing Rate (UBIR).

When demand occurs during a shortage period it is frequently partially backordered or partially lost with a backlogging rate. We consider a decentralized multi-echelon supply chain in which each party does not have full information of the negative inventory levels or next replenishment times in the preceding stages. Therefore supplier's negative inventory level or inventory cycle does not influence a buyer's decisions to remain loyal or to switch to a different supplier. Thus we assume a constant percentage r of the demand during shortage is backlogged and the rest is lost with a constant unit lost sales cost.

This paper is organized as follows. In section 2, a linear model is developed with the notation and assumptions defined. In section 3 an optimization procedure for minimizing the total relevant cost is described. The lemma and theorem proofs, numerical examples and sensitivity analysis are available upon request.

THE MODEL

We assume the backorder cost per unit time per unit order $[\$/unit/time\ unit]$ is linear in the time already backlogged, i.e.,the per unit order per unit time backorder cost at time t for an order placed at t_0 is

$$C_0 + b(t - t_0)$$

t	current time(a point in time during the stock out period)
t_0	order placement time of a backorder
b	per unit per unit time backorder cost increasing rate (UBIR); $b \geq 0$
C_0	unit fixed backorder cost per unit time

We assume a constant demand rate α, of which $r\alpha$ is backlogged and the rest $(1-r)\alpha$ is lost during the shortage period. Therefore, the total number of units of backorder during stock out period is

$$r\alpha(T - t_1)$$

and the total number of lost sales is

$$(1 - r)\alpha(T - t_1).$$

Thus, the total backorder cost in one inventory cycle is

$$\int_{t_1}^{T} r\alpha \int_{t_0}^{T} [C_0 + b(t - t_0)]dtdt_0$$
$$= r\alpha\{\frac{b}{6}(T - t_1)^3 + \frac{C_0}{2}(T - t_1)^2\}$$

r = backlog rate of the demand during shortage period
α = constant demand rate
T = cycle time
t_1 = time to which inventory is positive; $t_1 \leq T$
The total relevant cost per unit time (for instance, per year) is

$$TRC(T, t_1) = \frac{1}{T}\{A + \frac{Cit_1^2\alpha}{2} + r\alpha[\frac{b}{6}(T - t_1)^3 + \frac{C_0}{2}(T - t_1)^2] + R(1 - r)\alpha(T - t_1)\} \tag{3.1}$$

R	= fixed opportunity cost of a lost sale
C	= unit cost of the item
A	= ordering cost per order
i	= inventory carrying cost fraction per unit per unit time
$TRC(T, t_1)$	= total relevant cost per unit time

MODEL OPTIMIZATION

Our problem is to minimize total relevant cost $TRC(T, t_1)$

$$\begin{aligned} Min \quad & TRC(T, t_1) \\ s.t. \quad & t_1 \leq T \\ & t_1 \geq 0 \\ & T \geq 0 \end{aligned}$$

Lemma 1. *For any given $T > \frac{R(1-r)}{Ci}$, TRC with $0 \leq t_1 \leq T$ has a minimum value at the interior of the interval $0 < t_1^* < T$ and the optimal t_1^* satisfies $t_1^* > \frac{R(1-r)}{Ci}$. For any $T \leq \frac{R(1-r)}{Ci}$, TRC with $0 \leq t_1 \leq T$ has a minimum value at $t_1 = T$.*

In practical terms, if the inventory cycle time T is predetermined, Lemma 1 presents a guideline concerning whether shortage should be scheduled or not. If T is greater than $\frac{R(1-r)}{Ci}$, the optimal policy is to allow some shortage period. However, we should hold positive inventory for longer than $\frac{R(1-r)}{Ci}$, otherwise the shortage is scheduled too long to be cost efficient. If the current inventory cycle is less than or equal to $\frac{R(1-r)}{Ci}$, holding inventory throughout the cycle is optimal. The optimal solution is the classical EOQ model with $t_1^* = T^* = \sqrt{\frac{2A}{Ci\alpha}}$.

Lemma 2. *For any given $t_1 \geq \frac{R(1-r)}{Ci}$, there is a unique T, i.e.,*

$$T = t_1 + \frac{-rC_0 + \sqrt{(rC_0)^2 + 2rb[Cit_1 - R(1-r)]}}{rb}, \tag{4.1}$$

such that $T \geq t_1$ and T satisfies $\frac{d}{dt_1}TRC(t_1|T) = 0$. For any $t_1 < \frac{R(1-r)}{Ci}$, $\frac{d}{dt_1}TRC(t_1|T) = 0$ does not have a solution with $T \geq t_1$.

Lemma 3. *If $Ci > \frac{R^2(1-r)^2\alpha}{2A}$, $TRC(T)$ is convex on $T > t_1(T) > \frac{R(1-r)}{Ci}$.*

The first order condition of TRC with respect to T is

$$\frac{d}{dT}TRC(T) = \frac{1}{T}\{r\alpha[\frac{b}{2}(T-t_1)^2 + C_0(T-t_1)] + R(1-r)\alpha\} - \frac{TRC}{T} = 0 \tag{4.2}$$

From $\frac{d}{dt_1}TRC(t_1|T) = 0$ (proof available upon request) we know that at optimality

$$r[\frac{b}{2}(T-t_1)^2 + C_0(T-t_1)] + R(1-r) = Cit_1$$

Substituting this into (4.2) we have

$$\alpha Cit_1 = TRC = \frac{1}{T}\{A + \frac{Cit_1^2\alpha}{2} + r\alpha[\frac{b}{6}(T-t_1)^3 + \frac{C_0}{2}(T-t_1)^2] + R(1-r)\alpha(T-t_1)\} \tag{4.3}$$

Because at optimality, both T and $T - t_1$ are functions of t_1 (4.1), let

$$T - t_1 = \theta(t_1) \quad T = \phi(t_1), \tag{4.4}$$

substituting 4.4 into (4.3) we obtain

$$Cit_1\phi(t_1) - \frac{Cit_1^2}{2} - r[\theta^3(t_1)\frac{b}{6} + \theta^2(t_1)\frac{C_0}{2}] - R(1-r)\theta(t_1) = \frac{A}{\alpha} \tag{4.5}$$

Define the function $f(t_1)$ as

$$f(t_1) = Cit_1\phi(t_1) - \frac{Cit_1^2}{2} - r[\theta^3(t_1)\frac{b}{6} + \theta^2(t_1)\frac{C_0}{2}] - R(1-r)\theta(t_1)$$

If $f(t_1) = \frac{A}{\alpha}$ is satisfied on $t_1 > \frac{R(1-r)}{Ci}$, we have $\frac{d}{dT}TRC = 0$ over the same range. Because TRC is convex in $T > t_1 > \frac{R(1-r)}{Ci}$ (Lemma 3), the corresponding $(t_1^*, \phi(t_1^*))$ in $f(t_1) = \frac{A}{\alpha}$ is the optimal solution. If $f(t_1) > \frac{A}{\alpha}$ for any $t_1 > \frac{R(1-r)}{Ci}$, TRC keeps

increasing on $t_1 > \frac{R(1-r)}{Ci}$, the optimal value of t_1 must be less than or equal to $\frac{R(1-r)}{Ci}$. To check whether $f(t_1)$ can be equal to $\frac{A}{\alpha}$, we derive the following lemma.

Lemma 4. *If* $2CiA - R^2(1-r)^2\alpha > 0$, $f(t_1) = \frac{A}{\alpha}$ *has solution* t_1^* *on* $(\frac{R(1-r)}{Ci}, +\infty)$. *The optimal solution for* TRC *satisfies*

$$T^* = t_1^* + \frac{-rC_0 + \sqrt{(rC_0)^2 + 2rb[Cit_1 - R(1-r)]}}{rb} > t_1^* > \frac{R(1-r)}{Ci}$$

and the minimum total relevant cost $TRC(T^*, t_1^*) = Ci\alpha t_1^*$.
If $2CiA - R^2(1-r)^2\alpha \leq 0$, $f(t_1) > \frac{A}{\alpha}$ *for any* t_1 *on* $(\frac{R(1-r)}{Ci}, +\infty)$, *there is no optimal solution* t_1^* *for* TRC *on* $(\frac{R(1-r)}{Ci}, +\infty)$.

Summarizing above lemmata, we develop the following theorem.

Theorem 1. *If* $Ci > \frac{R^2(1-r)^2\alpha}{2A}$, *the optimal inventory policy is to hold positive inventory for a duration of* t_1^* *per cycle, where* t_1^* *satisfies (4.5); and schedule shortage period for a length of* $\frac{-rC_0+\sqrt{(rC_0)^2+2rb[Cit_1-R(1-r)]}}{rb}$ *per cycle. The minimum total relevant cost is* $Ci\alpha t_1^*$. *If* $Ci \leq \frac{R^2(1-r)^2\alpha}{2A}$, *the optimal policy is to schedule EOQ inventory cycle of* $T^* = t_1^* = \sqrt{\frac{2A}{Ci\alpha}}$ *with no shortage period, the minimum total cost is* $TRC(T^*, t_1^*) = Ci\alpha T^* = \sqrt{2CiA\alpha}$.

Theorem 1 shows whether shortages should be planned deliberately depends on the tradeoff between the costs of holding inventory and lost sales. When inventory holding costs are relatively greater than lost sales cost, the optimal policy is to incur some shortages. Otherwise, the optimal policy is to have no shortage scheduled.

Note that the criterion derived in theorem 1 does not depend on the backorder cost parameters b or C_0. When $r = 0$ this result coincides with the known complete lost sales model [7] and [1].

SUMMARY AND CONCLUSIONS

It has been shown that firms that maintain a backlog of orders as normal business practice can be successful. [3]. While scheduling shortage intentionally as a business norm has been widely accepted, few precise quantitative guidelines is provided as to in what situation shortage is desired and how long should it be scheduled to provide most cost efficiency and operations flexibility. This paper investigates the supplier's situation of linear increasing unit backorder cost and proposes the criterion of optimal solutions. Our result suggests that when the set-up cost, the unit cost and the inventory carrying cost are relatively high such that $Ci > \frac{R^2(1-r)^2\alpha}{2A}$, the supplier should schedule a limited shortage period. The length of the shortage depends on UBIR. Otherwise the optimal policy is to have no shortage scheduled. Either case the supplier should schedule a limited inventory cycle.

In practice, the stock shortage can not be extended infinitely. End customers will turn to other sellers and the good will loss will ultimately hurt the supplier and its downstream parties in the long run. In the model of Chu et al. [3], the supplier has

the incentive to delay backorder delivery as long as the shortage cost is small enough compared to inventory holding and other costs. To prevent this scenario we suggest dictating increasing unit backorder penalties in the contracts to reflect the realistic chain effect of backorder cost through the supply chain. According to our model the supplier will schedule limited or zero shortage to minimize its total relevant cost. The supply chain is protected from the snowball effects of shortage, which is more possible to happen in today's JIT environment because each tier holds less inventory and relies more upon the on-time delivery from its supplier.

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SUPPLIER RELATIONS AND SUPPLY CHAIN PERFORMANCE: AN EXPLORATORY EMPIRICAL STUDY OF FINANCIAL SERVICES PROCESSES

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ABSTRACT

Supply chain management has increasingly been recognized as a key driver of overall operational and financial performance. In this study we focus on supplier relations in financial services processes and empirically examine the relationship between supplier relations and supply chain performance using a unique database with a sample of 108 financial services processes. Our results show that, after controlling for supplier efficiency and responsiveness, use of information technology, electronic information-sharing, and supplier type, better supplier relations are associated with satisfaction with overall supplier performance. However, the "relational" components of the relationship (cooperation and long-term commitment) are correlated with satisfaction with overall supplier performance, while the "operational" components of the relationship (high degree of coordination, information-sharing, and feedback) are not.

Keywords: Supply chain management, Supplier relations, Financial services, Service processes

INTRODUCTION

Supply chain management has increasingly been recognized as a key driver of overall operational and financial performance [6]. As such, researchers have been examining various aspects of supply chain management, including managing supplier relations. Arguably, better supplier relations should result in better supply chain performance. However, research has shown that the "obvious" relationship between supplier relations and supply chain performance is, in fact, nuanced, and depends on what is being done under the umbrella of "supplier relations" and how it is being done.

In this study we empirically examine the relationship between supplier relations and supply chain performance with a sample of 108 financial services processes. The study is unique because supplier relations and supply chain performance has previously been examined at the SBU or firm level and not at the process level. This is particularly important for service processes because, unlike manufacturing, services are often not procured and managed centrally [3], so the process may be a more appropriate level of analysis. Further, using a database that includes intra-firm as well as inter-firm supply chains allows us, for example, to include internal/external supplier as a control variable before determining the association between supplier relations and perceptions of overall supplier performance. In addition, most empirical supply chain studies have been done in a manufacturing context [15] [16] [20] [21], while this study examines satisfaction with supplier performance in a service (i.e., financial services) context. Because the "product" in financial services tends to be information rather than something more tangible (greatly impacting the ability of service processes to respond to demand

uncertainty through the use of inventory) and specifications and performance criteria for intangible products are typically more ambiguous [3], supplier relations management and its relationship to supply chain performance may not be generalizable from manufacturing to services.

Our results show that, after controlling for supplier efficiency and responsiveness, use of information technology, electronic information-sharing, and supplier type, better supplier relations are associated with satisfaction with overall supplier performance. However, the "relational" components of the relationship (cooperation and long-term commitment) are correlated with satisfaction with overall supplier performance, while the "operational" components of the relationship (high degree of coordination, information-sharing, and feedback) are not.

LITERATURE REVIEW AND HYPOTHESES

The operations management literature has a number of studies examining the relationship between supplier relations and supply chain performance. While supplier relations are often discussed as a general concept, most of the empirical studies look at specific aspects of managing supplier relations, such as collaboration and cooperation, with few looking holistically at the relationship between the supply chain partners. In this section, we review this literature stream as a basis for the hypotheses we then test.

Based on our review of the literature, we consider supplier relations to be represented by five key dimensions – coordination, cooperation, commitment, information-sharing, and feedback [2] [5] [8] [14] [18]. Overall, previous findings suggest that better supplier relations should be positively associated with supplier performance. However while these five dimensions are often individually found to be positively associated with supplier performance, this is not always the case. Moreover, *satisfaction* with overall supplier performance may also be subject to the perceived value of the relationship in terms of the costs versus the benefits. Thus, we state the following two hypotheses.

H1: Better supplier relations will be positively associated with satisfaction with overall supplier performance.

H2: Different dimensions of supplier relations will have varying associations with overall supplier performance.

To test these hypotheses we need to include a number of control variables that the literature suggests have a bearing on satisfaction with overall supplier performance. First, the *actual* supplier performance, in terms of efficiency and responsiveness [4], should have a positive association with satisfaction with overall supplier performance. Second, researchers have suggested that high-performing supply chains are information intensive and that the use of information technology is essential for managing supply chain activities [6] [12] [22]. However, other findings are less conclusive. Hill and Scudder [10] find that firms consider electronic data interchange (EDI) more as a tool for improving efficiencies than as a tool for facilitating supply chain integration. The scope of information technology use is a significant predictor in Japan but

not in the U.S. [1]. Thus, based on this literature we control for the use of information technology by the respondent's process and electronic information-sharing in the supply chain. In addition, IT infrastructure integration has been found to affect performance [19]. As such, we include an interaction between electronic information-sharing and the use of information technology to determine if the effect of electronic information-sharing on satisfaction with overall supplier performance depends on the level of information technology use.

As mentioned above, the supplier type (internal to the firm or external to the firm) is also included as a control variable. It has been argued that the external customer's satisfaction is related to the performance of all the internal processes for producing the product [7] [23] [24]. Thus, meeting the needs of internal customers helps ensure external customer satisfaction. However, Lee and Billington [11] note that discrimination against internal customers occurs because, unlike external customers, internal customers do not bring in real revenue. Thus, internal suppliers may consider them less valuable and of lower priority, resulting in poorer performance. In the vertical integration literature, researchers suggest that dulled incentives and reduced flexibility to change partners in vertically integrated firms could result in higher costs, poorer quality, or poorer performance in general [13] [17]. This argument has been made at the internal process level as well, with negative performance implications for internal customers [7]. This suggests that the customer's satisfaction with overall supplier may be different depending on whether the supplier is internal or external to the firm.

METHODS, RESULTS AND CONCLUSIONS

To test *H1*, we conducted a regression analysis, including the control variables and supplier relations construct. . To test *H2* we computed the correlations between the individual items that make up the construct and satisfaction with overall supplier performance.

The results show that the supplier relations construct is positively associated with satisfaction with overall supplier performance ($p<0.05$, one-tailed test), providing support for *H1*. Regarding *H2*, having a cooperative relationship with suppliers, and having a long-term commitment are highly positively correlated ($p<0.01$) with satisfaction with overall supplier performance; having a high degree of coordination, information-sharing, and feedback with suppliers are not. These results support *H2*, which states that different supplier relations dimensions will have varying associations with satisfaction with overall supplier performance.

With respect to the second hypothesis, in particular, we found cooperation and long-term commitment, two characteristics of supplier relations that are more "relational" in nature, are significantly positively correlated with satisfaction with overall supplier performance, while coordination, information-sharing, and feedback, which are more "operational" in nature, are not correlated with satisfaction with overall supplier performance. Because the context of our study is in services, one possible explanation for the results is the more ambiguous nature of service products (compared to manufactured products) increasing the importance of the relational aspects supplier relations.

From a managerial perspective, our study suggests the importance of improving supplier relations to increase satisfaction with supplier performance in a services industry. What is perhaps more interesting is that a focus on the operational aspects of managing supplier relations,

while not hurting satisfaction, does not necessarily increase satisfaction. It may be that the information and other systems that are used for coordination, information-sharing, and feedback are considered "order qualifiers" (i.e., a necessary and expected part of supply chain management), thereby having little association with satisfaction with supplier performance [9]. While operational aspects of supplier relations are certainly necessary for the smooth functioning of the supply chain, it appears that a more important source of *satisfaction* is associated with building relationships within the supply chain through cooperation and long-term commitment. Thus, managers need to focus not only on the technical aspects of supply chain management but also facilitate relationship-building as well.

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DEVELOPMENT OF A DECISION MODEL FOR SUPPLIER SELECTION

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Abstract: The purpose of this study is to develop a model to help decision makers with their sourcing decisions. The attempt here is to develop a model that provides guidelines for the decision makers for selecting the appropriate supplier once their sourcing option is determined to be a sound decision. The intangible benefits and costs (risks) of outsourcing are identified, and the importance of these risks and benefits for the decision maker is solicited. In addition, the decision maker's perceptions on the likelihood of delivery of these risks/benefits by potential suppliers are included in the analysis.

I. INTRODUCTION

The published literature on outsourcing can be divided into two general categories: the first category deals with the *outsourcing decision* by identifying risks and benefits of outsourcing, and the second category is the related area of *supplier selection.* Focus of this study is on the second category, supplier selection. A brief overview of the works done in this area follows:

Supplier Selection is the focus of many published literature since choosing the right supplier is the key to success of every outsourcing decision. Several analytical approaches have been introduced in the literature for evaluating suppliers. These techniques along with the corresponding authors are listed below:

Title of the model or technique	**Authors**
categorical method	Timmerman, 1986
vendor performance matrix approach	Soukup, 1987
Vendor profile analysis (VPA)	Thompson, 1990
Analytical Hierarch Process (AHP)	Nydick & Hill, 1992
Fuzzy Analytical Hierarchy Process	Kahraman et al, 2003
Multi-Objective Programming (MOP)	Weber & Ellram, 1993
Multi-Attribute Utility Theory (MAUT)	Min, 1994
Cost-ratio models	Dobler et al, 1990 Kemp, 2002
AHP and Muti-Attribute Utility Theory combined	Teng & Jaramillo, 2005
Price, cost, and value analysis approach	Batdorf & Vora, 1983
Customer Relationship Management (CRM) and Supplier Relationship Management (SRM)	Choy et al, 2004
Multi-attribute Analysis	Mclover & Humphreys, 2000
Multivariate Analysis	Lasch & Janker, 2005
Generic Supplier Management Tool (GSMT) using Case Based Reasoning (CBR)	Choy & Lee, 2003
various mathematical techniques	Cebi & Bayraktar, 2003

	Barla, 2003
	Dogan & Sahin, 2003
Total Cost of Ownership and AHP	Bhutta & Huq, 2002
Dynamic strategic decision model using Analytical Network Process (ANP)	Sarkis & Talluri, 2002
Interpretive Structural Modeling (ISM)	Mandal & Deshmukh, 1994
Dimensional Analysis	Willis et al., 1993
Human Judgment Models	Patton, 1996
VSS for cooperative customer/supplier relationships	Masella & Rangone, 2000
Principal component analysis	Petroni & Braglia, 2000
Linear Programming and AHP	Ghodsypour & O'Brien, 1998

Most of the work has been focused on identifying the relevant attributes utilized in supplier selection decisions. However, little study is done to bring in the risks and/or benefits of outsourcing in the evaluation of the potential suppliers. Even fewer attempts have been done to reflect the decision maker's perception on the importance of these factors and the likelihood of delivery of these risks/benefits by suppliers. The attempt here is to enhance the evaluation process by including the benefits/risks of outsourcing as well as the decision maker's judgment on the importance of these factors in the decision model.

The decision model developed here includes both intangible costs (risks) and benefits of the outsourcing option in the evaluation process. The potential suppliers are then evaluated based on obvious and tangible factors as well as the less tangible factors. The importance of these intangible benefit/risk factors varies by decision makers. Also the likelihood of them being materialized depends on decision maker's perception of the performance of the supplier. To reflect this, the decision maker's preference and perception are elicited through a set of utility questions. A supplier is then selected based on their performance with respect to these risk and benefit categories. By evaluating suppliers based on strategic factors both tangible and intangible, the decision maker can make a more informed decision that is in line with the firm's long-term objectives rather than using outsourcing as a quick-fix and a preventive measure.

Detailed explanation of different segments of the model is covered in section II, and the paper closes with concluding remarks in section III.

II. SUPPLIER SELECTION PROCESS

The purpose here is to identify the best supplier based on both quantitative and qualitative attributes. Suppliers are compared with respect to the benefits they offer and importance of these benefits to the decision maker. In addition, the level of risk associated with an outsourcing decision is measured for each supplier. The supplier that offers the most benefits with minimum risks is the optimal choice. Supplier selection process has two phases: economic justification phase and selection phase which are explained below:

Economic Justification Phase: Even though the sourcing decision is determined to be strategically sound, the economic feasibility of such decision should be considered as well. Economic justification starts with calculation of all costs associated with the

sourcing decision. The total cost of outsourcing for each potential supplier/vendor is calculated. These total costs are then compared with the cost of producing the product or providing the service in-house.

To calculate total outsourcing costs and in-house production costs, the individual cost elements should be identified. The in-house cost elements are: labor costs, material costs, capital costs, and overhead costs. The outsourcing cost elements are: unit purchase price, transportation costs, administration costs, and other costs. Detailed definitions of these costs are provided by (Ordoobadi, 2005).

Total Cost $_{(\text{in-house})}$ $TC_{\text{in-house}}$: Total in-house production cost is the sum of labor costs, material costs, capital costs, and overhead costs.

Total cost $_{(\text{outsourced})}$ $TC_{\text{outsource}}$: Total outsourced cost is the sum of the purchase price, transportation costs, administrative costs, and other costs.

Now, Δcosts function can be defined as: $\Delta\text{costs} = Tc_{\text{in-house}} - TC_{\text{outsource}}$

if Δ costs > 0 outsourcing has cost advantage

if Δ costs < 0 producing in-house has cost advantage

In the case that outsourcing has cost advantage, it means that the outsourcing decision is economically feasible. If total sourcing costs exceeds the in-house costs, the outsourcing decision is not economically feasible. However, in both cases, the calculation of sourcing and in-house total costs is based solely on tangible factors that are quantifiable. Thus, the conclusions made based on the result of an economic evaluation might not be totally valid. The inclusion of intangible factors associated with an outsourcing activity could very well reverse the result of the economic analysis. Therefore, intangible benefits and costs (risks) of sourcing should be identified and included in the analysis to provide a more accurate justification mechanism.

Thus, regardless of the result of the economic analysis, the model proceeds to the next phase of ranking and selection of a supplier. In the case of economically justified sourcing decision, the purpose is basically ranking of the suppliers and then selecting the "right" supplier. For the case that sourcing is economically infeasible, the main task is to test if the inclusion of intangibles could make the sourcing option more attractive. The ranking of the suppliers then follows. In the following section, this procedure is explained in detail.

Selection Phase: The selection process starts by using the result of the economic analysis. The economic analysis result will be enhanced by inclusion of the intangible factors to allow a more accurate comparison of the suppliers by considering not only the obvious tangible costs of outsourcing but intangible costs and benefits as well. The selection process is conducted for two cases: 1) Δcosts <0; 2) Δcosts >0; The explanation of these two scenarios follows:

***1. A negative gap exists between outsourcing costs and in-house production costs (*Δ*cost*<.**0)**. That is, the outsourcing costs are more expensive than the in-house production costs. Of-course the magnitude of the gap between the sourcing costs and in-house production costs is very important in determining whether inclusion of the intangibles is even an option. The decision maker will decide how small the gap should be to warrant further considerations. Thus, a maximum acceptable level for the gap is set by the decision maker. If the gap between the sourcing costs and the in-house production costs is above the maximum acceptable level, then no further analysis is needed. The sourcing decision is not justified and should be postponed for now. In other words, the

decision maker believes that the economic gap is too large to be compensated by inclusion of the intangible factors in the analysis.

A gap less than the maximum acceptable level might be compensated by considering intangibles. The importance of these intangibles varies for each decision maker. The intangibles associated with any outsourcing activity could fall into two categories: intangible benefits, and intangible costs (risks). Both of these categories should be included in the selection phase. However, they are treated differently in the evaluation process. Detailed explanation of the evaluation of the intangible benefits and risks categories follows.

Evaluation of Intangible Benefits: A list of possible benefits that could materialize from a sourcing decision is provided for the decision maker's evaluation. This list is compiled from the available literature on the subject. Some benefits offered by outsourcing cited in the literature are (Chalos 1995, McCarthy 1996):

- Higher level of flexibility, with less restriction from the rules existing in the company.
- Increased responsiveness to customers' needs.
- Providing special services to the customers through outsourcing without the need to hire special skill workers.
- Liability and risk reduction. Outsourcing can reduce many sources of risk and potential liability faced by manufacturers like: safety, EEO, ADA, workers' compensation, etc.
- Reduction of capital investment and labor requirements.
- Lower capital risk.
- Access to the innovations and developments of more specialized suppliers.
- Reduction of cost because of the supplier's economies of scale.
- Greater focus of resources on high value-added activities and core business.

Not all benefits are pertinent to the organizational goals and some are more important than others. The decision maker first selects the benefits that are relevant to his/her situation. The decision maker is then asked to rank these benefits from very important to somewhat important. Thus, the list of benefits is narrowed down by eliminating the ones that are not pertinent to the organization's outsourcing activity.

The likelihood of each of the important benefits being delivered by suppliers is also very critical in the evaluation process. The determination that certain benefits of outsourcing are very important to the decision maker is not enough unless the suppliers can actually deliver these benefits. Thus, the decision maker's perception on the likelihood of receiving important benefits from each supplier is elicited. The decision maker can use historical data on suppliers' performance or personal judgment to assign likelihood ratings to potential suppliers. Suppliers then will be assigned a score based on the likelihood rating and importance ranking that they have received from the decision maker.

Evaluation of Intangible Costs: Any sourcing decision has certain risks (costs) that might not be quantifiable to be included in the calculation of outsourcing costs. Thus, these risk factors should also be identified and included in the evaluation process as was done for the intangible benefits. Therefore, a list of intangible costs (risks) that could materialize from a sourcing decision is provided for the decision maker's consideration.

This list is compiled from the available literature on the subject. Some of the risks associated with outsourcing cited in the literature are(Friedman 1991, Raistrick 1993):

- Lack of control on the quality of the product/service provided by the suppliers.
- Inability to meet fluctuations in demand for the product/service that has been outsourced.
- Loss of control over suppliers. Possibility of suppliers becoming a competitor for the firm themselves or assisting the firm's competitors.
- Negative impact on employees' morale.
- Loss of critical skills or developing the wrong skills.
- loss of cross-functional skills.

Not all risk categories are pertinent to the outsourcing activity in question, and some are more important than others. The decision maker first selects the risk categories that are relevant to his/her situation. The decision maker is then asked to rank these risk factors from very important to somewhat important. These rankings are associated with how badly the decision maker wants to avoid the risk. A very important ranking assigned to a risk factor means that it is critical for the firm to avoid this risk factor. A very low importance ranking assigned to a risk factor means that the company probably can live with that risk factor.

The likelihood of the relevant risk categories being delivered by a supplier is also very important and should be considered in the evaluation process. Thus, the likelihood ratings associated with these factors are elicited from the decision maker based on his/her perception. Historical data, and/or decision maker's personal judgment can be used for assigning these likelihood ratings to different suppliers. The potential suppliers are then assigned a score based on their importance ranking and likelihood ratings.

The results of the two previous analyses are combined to come up with the list of suppliers that meet both requirements. Namely, high likelihood ratings associated with important benefits and low likelihood ratings associated with important risk factors. This new list will be used for the selection purpose. The decision maker will rank the remaining suppliers on the list. The ranking of the suppliers is done by using a scoring scheme to come up with a final score for each potential supplier.

The scoring scheme proposed here is based on assigning individual scores to each supplier for the combinations of importance ranking and likelihood rating of the costs categories as well as benefits categories. The aggregate score that a supplier receives is then calculated by adding his/her individual scores from the costs and benefit categories. The mechanism for assigning scores to the suppliers and calculations of the aggregate scores is built into the model and is done internally once the decision maker's preferences and perceptions on the importance ranking and likelihood ratings are elicited. Obviously, this scoring scheme will be different for costs and benefits. The following ranking scheme is proposed:

Benefits	**supplier's score**	**Risks**	**supplier's score**
(VI, HL)	6	(VI, UL)	6
(I, HL)	5	(I, UL)	5
(VI, L)	4	(I, L)	4
(I, L)	3	(VI, L)	3
(I, UL)	2	(I, HL)	2
(VI, UL)	1	(VI, HL)	1

where, VI: very important; I: important; HL: highly likely; L: likely; and UL: unlikely

For example, a supplier that the decision maker believes is highly likely to deliver a very important benefit (VI, HL) will get the highest score, while a supplier that in decision maker's opinion has very small possibility of delivering a very important benefit (VI, UL) will receive the lowest score. The scoring would be in reverse order while considering risks of outsourcing. That is, if a decision maker believes that it is unlikely that a supplier will deliver a very important risk category (VI, UL); this supplier receives the highest score.

Of-course, the above proposed scheme is just one of many different scoring schemes that can be used to rank the potential suppliers. Each firm can develop its own unique ranking scheme. The decision maker can use linear weighting model or any other technique for selection purposes. Some decision makers might feel that different weights should be assigned to benefits and risk factors. Some prefer to assign equal weights to both benefit and risk factors. Based on the ranking scheme used by the decision maker, the supplier with the highest ranking is selected.

2. The outsourcing option is cheaper than the in-house production alternative (Δ ***cost> 0)***. That is the outsourcing activity is financially justified and the ranking of the suppliers is the main focus here. The suppliers can be ranked according to their cost of providing the service. However, a selection based on this ranking is inaccurate, since the ranking is based solely on tangible factors. The ranking of the suppliers could very well change by inclusion of the intangible benefits/costs that could materialize from an outsourcing decision. Thus, a list of intangible factors is provided for the decision maker to include in his/her evaluation process. The importance ranking and likelihood ratings are elicited from the decision maker in the same manner as mentioned in the previous case. Suppliers will be assigned scores based on the combination of importance rankings and likelihood ratings of the cost and benefit categories. The supplier with the highest score will then be selected.

III. CONCLUSIONS

An analytical model was presented to help the decision makers with their outsourcing decisions. The model is intended to answer one basic question: assuming that outsourcing decision is strategically sound, *which supplier should the firm select for outsourcing?* The supplier selection criteria are based on both quantitative as well as qualitative factors. The tangible cost/benefit factors as well as less tangible and strategic factors are included in the evaluation process and ranking of the suppliers. The decision maker will identify the benefits and risks of outsourcing that are pertinent to the firm's objectives. These benefits and risks are then ranked according to their importance. The decision maker's perception on the likelihood of these benefits/risks being delivered by suppliers also elicited. The combined analyses provide a narrowed list of suppliers that will be used for final selection. This proposed model helps the decision makers make a more informed decision regarding their sourcing decisions.

"References available upon request from [Sharon Ordoobadi]"

SUPPLIER SELECTION IN A CLOSED-LOOP SUPPLY CHAIN NETWORK

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INTRODUCTION

The growing interest in reverse logistics has many reasons, of which, consumers and governments concerns for environment being the primary reason. The growing desire of customers to acquire the latest technology, along with the rapid technological development in every industry, has led to a new environmental problem: "waste", consisting of both end-of-life products and used products (products that are discarded prematurely). Increased consumption results in increased use of raw material and energy, thereby depleting the world's finite natural resources. This environmental degradation is not sustainable by the earth's eco-system [1]. This environmental issue, in addition to government regulations is the major driving force for companies to engage in the reverse supply chain activities. Apart from the environmental regulations, reverse supply chains reduce the operating costs by reusing products or components [2].

A reverse supply chain consists of a series of activities required to retrieve a used-product from a consumer and either recover its left over market value or dispose it off. The combination of traditional/forward supply chain and reverse supply chain forms the closed-loop supply chain (CLSC). While this process is mandatory in many European nations, it is still in its infancy in the United States.

PROBLEM ADDRESSED

While many authors address a variety of strategic, tactical and operational planning issues in reverse and closed-loop supply chains (for example see [3], [4], and [5]), the issue of supplier selection has not been addressed thoroughly. Supplier selection is one of the key decisions to be made in the strategic planning of supply chains that has far-reaching implications in the subsequent stages of planning and implementation of the supply chain strategies. In traditional/forward supply chain, the problem of supplier selection is not new. First publications on supplier selection in traditional/forward supply chains date back to the early 1960s [6]. Contrary to a traditional/forward supply chain however, the strategic, tactical and operational planning issues in reverse and closed-loop supply chains involve decision making under uncertainty. A typical supplier selection problem involves selecting the suppliers and assigning the order quantities to those suppliers taking into consideration numerous conflicting constraints. Traditionally, in supply chain literature, the supplier selection problem is treated as an optimization problem that requires formulating a single objective function. However, not all supplier selection criteria can be quantified, because of which, only a few quantitative criteria are included in the problem formulation.

METHODOLOGY

In this paper, we identify the critical criteria that influence the supplier selection problem in a reverse/closed-loop supply chain and develop an integrated multi-criteria decision making methodology using Taguchi loss functions, AHP and Goal programming techniques. While the Taguchi loss functions quantifies the suppliers attributes to quality loss, the AHP transforms these quality losses into a variable for decision making that can be used in formulating the goal programming objective function to determine the order quantities. A numerical example is presented to illustrate the proposed methodology.

Taguchi Loss Functions

According to Taguchi's quality philosophy, any deviation from a characteristic's target value results in a loss that can be measured by a quadratic loss function [7]. Taguchi proposed three types of loss functions: 1) Nominal value is the best, used when there is a finite target point to achieve, 2) Smaller-is-better, used where it is desired to minimize the result, with the ideal target being zero and 3) Higher-is-better, used where it is desired to maximize the result, the ideal target being infinity [8]. The three loss functions are shown in equations (1), (2) and (3) and figures 1, 2, 3 and 4 respectively [9].

$$L(y) = k(y - m)^2 \tag{1}$$

$$L(y) = k(y)^2 \tag{2}$$

$$L(y) = \frac{k}{y^2} \tag{3}$$

where, L(y) is the loss associated with a particular value of quality characteristic y, m is the nominal value and k is the loss coefficient. The quality losses of all the critical criteria for all the suppliers are calculated using the above mentioned loss functions.

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) [10] is a tool, supported by simple mathematics, which enables decision-makers to explicitly weigh tangible and intangible criteria against each other for evaluating different alternatives. The AHP in such cases is conducted in two steps: (1) Weigh independent criteria using pair-wise judgments, (2) Compute the relative ranks of alternatives using pair-wise judgments with respect to each independent criterion.

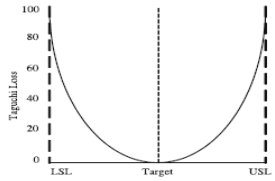

Figure 1. Nominal-the-better (equal specification)

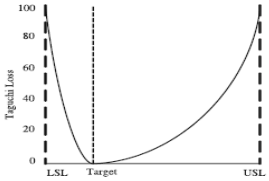

Figure 2. Nominal-the-better (unequal specification)

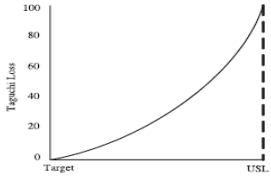

Figure 3. Smaller-the-better

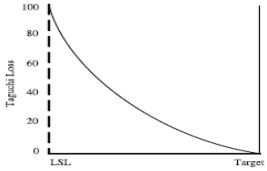

Figure 4. Larger-the-better

Ranking the Suppliers

Once the quality losses of all the critical criteria for all the suppliers are calculated using the above mentioned Taguchi loss functions and the weights of all the decision criteria are obtained by the AHP, the total loss of all the criteria to each supplier can be calculated by equation (4):

$$Loss_j = \sum_{i=1}^{n} W_i X_{ij} \tag{4}$$

where, $Loss_j$ is the total loss of supplier j for all the critical evaluation criteria, W_i is the weight of criterion i calculated by the AHP and X_{ij} is the Taguchi loss of criterion i of supplier j. Suppliers can be ranked based on the smallest to the largest loss; the best supplier is the one with the smallest loss [9].

Goal Programming

Goal programming (GP), generally applied to linear problems, deals with the achievement of specific targets/goals. This technique was first reported by Chanrnes and Cooper [11], [12] later extended in the 1960s and 1970s by Ijiri [13], Lee [14] and Ignizio [15]. The basic purpose of GP is to simultaneously satisfy several goals relevant to the decision-making situation. To this end, several criteria are to be considered in the problem situation on hand. For each criterion, a target value is determined. Next, the

deviation variables are introduced which may be positive or negative (represented by ρ_k and η_k respectively). The negative deviation variable, η_k, represents the under-achievement of the *k*th goal. Similarly, the positive deviation variable, ρ_k, represents the over-achievement of the *k*th goal. Finally for each criterion, the desire to over-achieve (minimize η_k) or under-achieve (minimize ρ_k), or satisfy the target value exactly (minimize $\rho_k + \eta_k$) is articulated [16].

Procedure to solve the GP model

The following steps are used to solve the GP model:

***Step* 1**: Read in all the relevant data, set the first goal as the current goal.

***Step* 2**: Obtain a linear programming (LP) solution with the current goal as the objective function.

***Step* 3**: If the current goal is the last goal, set it equal to the LP objective function value found in Step 2, STOP. Else, go to Step 4.

Step* 4:* If the current goal is just achieved or over-achieved, set it equal to its aspiration level and add this equation to the constraint set, go to Step 5. Else, if the value of the current goal is under-achieved, set the aspiration level of the current goal to the LP objective function value found in Step 2, go to Step 5.

Step* 5:* Set the next goal as the current goal, go to Step 2.

NUMERICAL EXAMPLE

We consider three suppliers for evaluation. For the qualitative evaluation using Taguchi loss functions and AHP, we consider four criteria: 1) Quality of the products delivered (smaller defective rate is better) 2) On-Time delivery (lesser the delays or early deliveries the better) 3) Proximity (closer the better) and 4) Cultural and Strategic Issues, that include level of cooperation and information exchange, supplier's financial stability/economic performance, supplier's green image, flexibility etc. Table 3 shows the relative weights of the criteria obtained after carrying out steps involved in AHP detailed in the above sections.

Table 1. Relative weights of criteria

Criteria	Relative Weight
Quality	0.384899
On-Time Delivery	0.137363
Proximity	0.052674
Cultural & Strategic Issues	0.425064

Table 2 shows the decision variables for calculating the Taguchi losses for the suppliers.

Table 2. Decision variables for selecting suppliers

Criteria	Target Value	Range	Specification Limit
Quality	0%	0-30%	30%
On-Time Delivery	0	10-0-5	10 days earlier, 5 days delay
Proximity	Closest	0-40%	40% higher
Cultural & Strategic Issues	100%	100%-50%	50%

To illustrate the calculation of Taguchi losses, consider for example the criteria, Quality. The target defect rate/breakage probability is zero at which there is no loss to the manufacturer and the upper specification limit for the defect rate/breakage probability is 30% at which there is a 100% loss to the manufacturer. Cultural and Strategic issues are hard to quantify. Monczka and Trecha [17] proposed a service factor rating (SFR) that includes performance factors difficult to quantify but are decisive in the supplier selection process. In practice, experts rate these performance factors. The ratings are given on a scale of 1-10, the level of importance being directly proportional to the rating. For a given

supplier, these ratings on all factors are summed and averaged to obtain a total service rating. The supplier's service factor percentage is obtained by dividing the total service rating by the total number of points possible. Column 8 in table 4 shows the service factor percentages of the sub-criteria considered under the Cultural and Strategic issues. We assume a specification limit of 50% for the service factor percentage, at which, the loss will be 100%, while there will be no loss incurred at a service factor percentage of 100%. Computing the value of loss coefficient, *k,* using appropriate equations (1), (2) or (3) gives a value of 1111.11, 625 and 25 for Quality, Proximity and Cultural and Strategic Issues. For On-Time delivery, $k_1 = 4$ and $k_2 = 1$. Table 3 shows the characteristic value and relative value of each criterion for the three suppliers. For supplier 1, the quality value is 15% defect rate, which translates to 15% deviation from target value. The relative values together with the value of loss coefficient, *k*, are entered into equations (1), (2) or (3) to compute the Taguchi losses for each supplier. Table 4 shows the Taguchi losses for each criterion calculated from the appropriate loss functions for the individual suppliers.

Table 3. Characteristic and Relative values of criteria

	Quality		On-Time Delivery		Proximity		Cultural & Strategic Issues	
Supplier	Value	Relative Value	Value	Relative Value	Value	Relative Value	Value	Relative Value
1	15%	15%	+3	+3	8	33.33%	57.5%	57.5%
2	20%	20%	+1	+1	6	0	62.5%	62.5%
3	10%	10&	-8	-8	9	50%	67.5%	67.5%

Table 4. Supplier characteristic Taguchi losses

Supplier	Quality	On-time Delivery	Proximity	Cultural & Strategic Issues
1	24.99	36	69.43	75.61
2	44.44	4	0	64
3	11.11	64	156.25	54.86

The weighted Taguchi loss is then calculated using the AHP weights from table 1 and equation (4). Table 5 shows the weighted Taguchi loss and the normalized losses for the individual suppliers.

Table 5. Weighted Taguchi Losses

Supplier	Weighted Taguchi Loss	Normalized Loss
1	50.36567	0.360148
2	44.86013	0.32078
3	44.62138	0.319072

Determining the Order Quantities

The second stage of the decision process uses goal-programming technique detailed above. The supplier's normalized losses calculated using the Taguchi loss functions and AHP as detailed above are used in formulating the goal programming objective function in addition to any system constraints present.

We consider two goals in our GP model:

1. Minimize the total loss of purchase (TLP)
2. Minimize the total cost of purchase (TCP)

It is at the discretion of the decision maker to add any other goals that are considered relevant to the situation to this proposed model.

Nomenclature used in the methodology

c_j = unit purchasing cost of product from supplier *j*, d_k = demand for product *k*, *g* = goal index, *j* = supplier index, j = 1, 2, …, s, $Loss_j$ = total loss of supplier *j* for all the critical evaluation criteria, r_j =

capacity of supplier j, p_j = probability of breakage of products purchased from supplier j, p_{max} = maximum allowable probability of breakage, Q_j = decision variable representing the purchasing quantity from supplier j, s = number of alternate suppliers available, w_i = weight of criterion i calculated by the AHP, X_{ij} = Taguchi loss of criterion i of supplier j.

Goal 1: Minimize TLP: $$\sum_{j=1}^{s} Loss_j * Q_j \quad (5)$$

Goal 2: Minimize TCP: $$\sum_{j=1}^{s} c_j * Q_j \quad (6)$$

Subject to:

$$Q_i \le r_i ; \sum_j Q_j = d_j \; ; \; d_k * p_{max} \ge \sum_{j=1}^{s} Q_j * p_j \text{ ; and } Q_j \ge 0 \quad (7)$$

Table 6 shows the data considered in the numerical example for the second stage of the decision-making process.

Table 6. Data for Goal Programming Model

Supplier	1	2	3
Capacity	300	650	750
Unit Purchasing Cost	1.2	0.9	1.0
Breakage Probability	0.03	0.015	0.01
Net demand for the product =1000			
Maximum acceptable breakage probability = 0.025			

The goal programming is solved using LINGO-8 and the above data; table 7 shows the results from our methodology.

Table 7. Results

Supplier	Normalized Taguchi loss	Quantity Ordered
1	0.360148	0
2	0.32078	543
3	0.319072	457
Total loss of purchase (TLP) = 320		
Total cost of purchase (TCP) = 945.7		

Supplier 3 is ranked first in terms of minimal Taguchi losses, if there are no other system constraints in place; all 750 units (supplier 3's capacity) may be ordered from supplier 3 before assigning order quantities to other suppliers. However, supplier 3's unit procurement cost is higher compared to supplier 2, whose normalized Taguchi loss is not much different from that of supplier 3. This, in addition to other system constraints in place leads to the results detailed in table 7.

CONCLUSIONS

Traditional supplier selection problems involve formulating a single objective function with the inherent risk of neglecting several critical criteria influencing the supplier evaluation and selection issue that cannot be quantified. To this end, in this paper, we proposed an integrated multi-criteria decision making methodology that used Taguchi loss functions, AHP and goal programming techniques. While the Taguchi loss functions quantifies the suppliers attributes to quality loss, the AHP transforms these quality losses into a variable for decision making that can be used in formulating the goal programming objective function to determine the order quantities. A numerical example was considered to illustrate the proposed methodology.

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MODELING MULTIPRODUCT PROCUREMENT DECISIONS WITH VOLUME DISCOUNTS

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ABSTRACT

This paper presents an analytical approach for simultaneous optimization of the number of vendors to employ and the order quantities to allocate to these vendors in a multi-product sourcing environment. The proposed approach can be used to support purchasing decisions in sourcing environments where vendors with varying prices quality and delivery performance levels offer volume discounts based on the total value of multi-product orders they receive from the buyer. The paper discusses the multicriterion nature of the purchasing decision, presents a multiobjective mathematical model, and proposes a solution methodology. Results of an extensive experiment show that the computational efficiency of the proposed model to be quite satisfactory.

Keywords: Purchasing, Vendor Selection, Volume Discounts, Multiobjective Programming

INTRODUCTION

Selecting vendors with various capabilities and performance levels from a large supplier base is a difficult and time-consuming task. In his seminal work on vendor selection criteria, Dickson [7] identified 23 different criteria by which purchasing managers have selected vendors in various procurement environments. In practice, procurement cost, product quality, delivery performance, and supply capacity have been found to be the most frequently used vendor evaluation criteria. A review of 74 supplier selection articles, by Weber et. al. [14] found that these four criteria received the greatest amount of attention in the recent literature.

The joint consideration of procurement cost, product quality, delivery performance, and supply capacity criteria complicates the selection decision because competing vendors have different levels of achievement under these criteria. For example, the vendor with the least expensive price in a given industry may not have the best delivery performance or product quality. Vendor selection is therefore an inherently multiobjective decision that seeks to reduce procurement cost, maximize quality, and maximize delivery performance concurrently.

The presence of volume discounts further complicates the selection problem since the buying decision is no longer based on a single product that can be purchased from one or more vendors, but on the collection of items that can be sourced from a single vendor. In this case discounts are based on the aggregate value of multi-product orders placed with the vendor over a given period of time, regardless of the magnitude or value of each order quantity. As such, vendor selection is a multicriterion decision that affects the number and types of vendors to employ, as well as the order quantities to place with these vendors.

This article introduces a multiobjective mixed integer programming model to support vendor selection decisions. The mathematical model is formulated in such a way to simultaneously determine the optimal number of vendors to employ and the order quantities they must supply to each facility or plant in the supply chain so as to concurrently minimize total purchase cost, maximize product quality, and maximize on-time deliveries, while satisfying capacity and demand requirement constraints.

MODEL DEVELOPMENT

Consider a procurement situation in which $i = 1, 2,\ldots, I$ items are to be purchased for $k = 1, 2,\ldots, K$ plants from $j = 1, 2,\ldots, J$ vendors, that provide different levels of item price, product quality, delivery performance, and supply capacity for each item they sell. Also, depending on the buyer's total purchases value vendor j offers a business volume discount having $r = 1, 2,\ldots, R_j$ discount brackets. For example a three-discount bracket schedule may be such that purchases worth less than \$100,000 get 0% discount, purchases worth \$100,000, but not exceeding \$500,000 get an across the board 5% discount applicable to all purchases, not just those above the \$100,000 cutoff point; and purchases worth \$500,000 are discounted 10% to \$450,000.

Let J_i be the set of vendors offering item i; I_j be the set of items offered by vendor j; K_j be the set of plants that can be supplied by vendor j; and K_i be the set of plants demanding item i. Also, let D_{ik} = units of item i demanded by plant k; c_{ijk} = unit price of item i quoted by vendor j for delivery to plant k; q_{ijk} = percentage of rejected item i units from vendor j at plant k; t_{ijk} = percentage of item i units from vendor j missing their scheduled delivery time window at plant k; S_{ij} = maximum quantity of item i that may be purchased from vendor j due to capacity constraints or other considerations; u_{jr} = upper cutoff point of discount bracket r for vendor j; and d_{jr} = discount coefficient associated with bracket r of vendor j's cost function.

Define decision variables as follows. x_{ijk} = units of item i purchased from vendor j for delivery to plant k. v_{jr} = volume of business awarded to vendor j in discount bracket r; observe that v_{jr} is greater than zero only if the dollar amount of purchases made from vendor j falls within bracket r of its cost function; otherwise it is zero.

$$y_{jr} = \begin{cases} 1, \text{if the volume of business awarded to vendor } j \text{ falls on segment } r \text{ of its cost function;} \\ 0, \text{otherwise.} \end{cases}$$

Mathematical Formulation

$$\min Z = [Z_1, Z_2, Z_3] \tag{1}$$

$$Z_1 = \sum_{j \in J} \sum_{r \in R_j} (1 - d_{jr}) v_{jr} \tag{1a}$$

$$Z_2 = \sum_{i \in I} \sum_{j \in J_i} \sum_{k \in K_j} q_{ijk} x_{ijk} \tag{1b}$$

$$Z_3 = \sum_{i \in I} \sum_{j \in J_i} \sum_{k \in K_j} t_{ijk} x_{ijk} \tag{1c}$$

subject to:

$$\sum_{j \in J_i} x_{ijk} = D_{ik}, \qquad i \in I, \quad k \in K_i; \tag{2}$$

$$\sum_{k \in K} x_{ijk} \le S_{ij}, \qquad i \in I, \quad j \in J_i; \tag{3}$$

$$\sum_{i \in I_j} \sum_{k \in K_i} c_{ijk} x_{ijk} = \sum_{r \in R_j} v_{jr}, \qquad j \in J; \tag{4}$$

$$v_{jr} \le u_{jr} y_{jr}, \qquad j \in J, \quad r \in R_j; \tag{5}$$

$$v_{j,r+1} \ge u_{jr} y_{j,r+1}, \qquad j \in J, \quad r = 1,..., R_j - 1; \tag{6}$$

$$\sum_{r \in R_j} y_{jr} = 1, \qquad j \in J; \tag{7}$$

$$y_{jr} = \{0,1\}, \ \ v_{jr} \ge 0, \qquad j \in J, \quad r \in R_j; \tag{8}$$

$$x_{ijk} \ge 0, \qquad i \in I, \quad j \in J_i, \quad k \in K_j. \tag{9}$$

Constraint (2) ensures that the total demand of each item at each plant will be satisfied. Constraint (3) ensures that the total number of items procured by each supplier to all plants is within the production and shipping capacity of that supplier. Constraint (4) determines the dollar amount of business awarded to vendor *j*. Constraints (5)-(6) link the purchase of the item with the business volume discount to the appropriate segment of the discount pricing schedule for each vendor. Constraint (7) ensures that only one discount bracket for each vendor's volume of business will apply. Constraints (8) and (9) ensure integrality and nonnegativity on the decision variables. Equation (1) specifies the multiobjective function whose components are given by equations (1*a*), (1*b*), and (1*c*). Equation (1*a*) minimizes the total purchase cost. Equation (1*b*) minimizes the number of defective items, and Equation (1*c*) minimizes the number of items missing their scheduled delivery time window.

A number of optional constraints may be added to the above formulation to account for additional requirements of the procurement decision. These constraints may be applied uniformly across all items and vendors or selectively to specific products or suppliers.

Market Share Constraint. This constraint specifies that the buyer is willing to purchase no more than a given percentage P_i of item *i* total demand ϕ_i from a given supplier. With $\phi_i = \sum_k D_{ik}$, this market share constraint may be expressed as: $\sum_{k \in K} x_{ijk} \le P_i \phi_i, \ \ i \in I, \ \ j \in J_i$. Whenever this option is selected, constraint (3) should be rewritten as: $\sum_{k \in K} x_{ijk} \le \min(S_{ij}, P_i \phi_i), \ \ i \in I, \ \ j \in J_i$. (3'). This way, constraint (3') enforces the dual requirement of supplier's capacity and supplier's market share without increasing problem size.

Business Volume Constraint. This constraint limits the buyer's volume of business with supplier *j* to a maximum dollar value U_j. Often, larger buyers would like to limit the amount of business they award to a single vendor to achieve their own supplier diversification goal, and also prevent small suppliers from becoming too dependent on them. This constraint is expressed as follows: $\sum_{r \in R_j} v_{jr} \le U_j, \ \ j \in J$.

Maximum Number of Supplier Constraint. This constraint limits the number of vendors the buyer is willing to do business with to a maximum of *M* suppliers. Often, decreasing the number of suppliers helps the buying organization reduce administrative cost due to individual transactions, and facilitate the development of long-term supplier partnerships. This constraint requires replacing constraint (7) by the following set of equations:

$$\sum_{r \in R_j} y_{jr} \leq 1, \qquad j \in J;$$

$$\sum_{j \in J} \sum_{r \in R_j} y_{jr} \leq M.$$

These optional constraints ultimately affect the type and number of vendors selected, their respective order quantities, as well as the total cost, quality and delivery outcomes of the procurement process.

SOLUTION METHODOLOGY

Two basic approaches may be used to solve multiobjective programming problems. These are the preference-oriented approach and the generating approach. The preference-oriented approach consists of techniques that rely on a formal characterization of preferences among the objectives prior to solving the problem. Generating techniques are suitable to situations where the articulation of preferences among the objectives is postponed until a range of alternative *noninferior* solutions is examined (see Cohon [5] for a comprehensive discussion). These solutions help the decision maker to better understand the tradeoffs between the objectives before selecting a best-compromise solution. Tradeoffs between the objectives are however relatively difficult to understand when more than two objectives are at hand. For this reason, practitioners often prefer the preference-oriented approach to generating techniques. An application of the preference-oriented approach to our problem is discussed next.

Preference Oriented Approach. Assume that our procurement manager is in a position to articulate a value judgment between the objectives of high product quality and on-time delivery in the form of some dollar value attached to such objectives. Let p_{ik} be the dollar penalty caused by one defective unit of item *i* at plant *k* to the purchasing organization. Also, let l_{ik} be the dollar penalty the organization suffers as a result of one unit of item *i* missing its scheduled delivery time window at plant *k*. The Multiobjective function (1) can now be rewritten as:

$$\min Z = \sum_{j \in J} \sum_{r \in R_j} (1 - d_{jr}) v_{jr} + \sum_{i \in I} \sum_{j \in J_i} \sum_{k \in K_j} p_{ik} q_{ijk} x_{ijk} + \sum_{i \in I} \sum_{j \in J_i} \sum_{k \in K_j} l_{ik} t_{ijk} x_{ijk}$$

or

$$\min Z = \sum_{j \in J} \sum_{r \in R_j} (1 - d_{jr}) v_{jr} + \sum_{i \in I} \sum_{j \in J_i} \sum_{k \in K_j} (p_{ik} q_{ijk} + l_{ik} t_{ijk}) x_{ijk} \qquad (1')$$

Equation (1') is a single dimension (dollars) objective function, and our model can be now solved as a single-objective optimization problem. The optimal solution to equation (1') subject to constraints
(2)-(9) represents the *best-compromise solution* for the chosen p_{ik} and l_{ik} values.

COMPUTATIONAL EXPERIENCE

An extensive computational experiment consisting of 192 different procurement environments obtained through the process of combining various values of the number of items, vendors, discount brackets, and plants was designed to test the computational efficiency of problem (1') - (9). The values of input factors were fixed as follows: items = 100, 200, and 300; vendors = 15, 20, 25, and 30; discount brackets = 3, 4, 5, and 6; plants = 1, 2, 3, and 4. For each such procurement configuration, 10 randomly generated problems were run on a personal computer using the LINGO optimization package, with the clock time elapsing between the beginning of the run and the reporting of the optimal solution recorded.

Results

Analysis of the optimization results reveals two observations. First, the proposed model is computationally efficient. The largest problem of 4 plants, 300 items, 30 vendors, and 6 discount brackets was solved to optimality in about 2 CPU minutes. Second, solution times appear to grow exponentially in the number of plants, but are relatively more sensitive to the number of vendors and their respective discount brackets than to the number of items.

Managerial Implications

The multiproduct procurement model developed in this paper includes a number of attractive features. The model is driven by multiple desirable objectives. The joint consideration of price, quality, and delivery performance in volume discount environments helps managers select vendors and allocate order quantity using a comprehensive approach that goes beyond just purchase costs. Furthermore, the ability of the model to capture local buying and centralized buying scenarios helps an organization choose between these two procurement strategies using this model. Additionally, the model could be extended to incorporate limits on the maximum number of suppliers to employ, supplier market share, and supplier business volume. The proposed model is computationally efficient and can be solved in a few seconds on a personal computer. As evidenced by the computational experiment even larger problems can be solved to optimality in a relatively short amount of computing time, making real-world applications of the proposed model both practical and realistic.

CONCLUSION

This paper introduced a multiobjective mixed integer programming model to support purchasing decisions in sourcing environments where competing vendors with different product quality and on-time delivery performance levels offer volume discounts based on the total value of multiproduct orders they receive from the buyer. The model can help an organization determines the optimal set of vendors to employ and allocates product order quantities to these vendors, in such a way to concurrently minimize total purchase cost, maximize product quality, and maximize on-time delivery reliability.

Optimal solutions to procurement decisions are a valuable tool. They eliminate much of the subjectivity that impacts such decisions under highly competitive and complex sourcing environments. To this end the proposed model provides a comprehensive yet computationally efficient approach that can be used to support purchasing decisions in such environments.

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Tactical and Strategic Information Sharing in the Supply Chain: An Empirical Analysis of EDI Exchange Between Trading Partners

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ABSTRACT

This paper examines the importance of tactical and strategic information sharing between supply chain partners. Through a transaction cost economics theoretical lens, we hypothesize that greater tactical and strategic information sharing volumes are associated with greater survival of supply chain relationships. We also hypothesize that a greater ratio of strategic to tactical information sharing is associated with supply chain relationship survival. The hypotheses are tested using an original data set of 42 firms, which include 24 manufacturers, six wholesalers, and twelve retailers. We find support for the two hypotheses that associate tactical and strategic information sharing with relationship survival.

INTRODUCTION

There is a growing interest in supply chain relationships as a source of competitive advantage. With an emphasis on the outsourcing of key inputs and non-core services, firms have increased their reliance on interfirm relationships. The traditional procurement approach of using arms-length exchanges to curtail the transfer of power in exchange relationships has given way to the Japanese procurement approach of using close supplier relationships as strategic assets. As firms focus on specific relationships and consolidate their procurement efforts, select supply chain relationships are terminated in order to reduce relationship management costs and leverage procurement dollars. In a drastic consolidation in supply relationships, Sony Corporation launched an initiative to reduce suppliers of production inputs from 4700 to 1000 over a three year period [4]. The Japanese supply chain model supports that the exchange of information between trading partners is critical to the coordination of interfirm resources. The question is then how firms can differentiate themselves in their supply chain relationships to ensure that the relationship is maintained and grown rather than terminated.

This paper makes several contributions to the growing research on information sharing among supply chain partners. First, the paper uses a transaction cost economics perspective to develop three hypotheses examining tactical and strategic information sharing among supply chain partners. The theory development is rooted in the context of firms who increasingly use information technology to facilitate information sharing in the supply chain. Second, the paper empirically tests the three hypotheses using an original data set of 24 manufacturers, six wholesalers, and twelve retailers. This empirical testing gives further insight into the importance of information sharing between supply chain members. Finally, the paper gives some managerial insight into the implications of this finding. In so doing, practitioners may be able to

better understand the importance of information sharing when developing their supply chain strategy.

THEORY AND HYPOTHESES DEVELOPMENT

Transaction cost economics provides an important theoretical foundation for an examination of information exchange and supply chain relationship survival. Within the transaction cost theory (TCT) framework, information is instrumental in both arms-length and close exchange relationships. Neoclassical economics assumes that full information is available to all market participants at no cost. This full availability of information to all exchange participants in the market allows the price mechanism to efficiently clear the market. Unfortunately, full information is rarely available to all parties of the exchange. Therefore, transaction costs are the result of coordination costs and transaction risk [5]. We propose hypotheses recognizing that transaction costs are reduced by the exchange of information due to the effects of differing levels of transparency on coordination costs and transaction risk.

Tactical information exchange, facilitated through information technology, lowers transaction costs between supply chain members. When order cycle information can be exchanged using standardized electronic formats, both the efficiency and the effectiveness of the supply relationship are improved [2]. Although any business document can be transmitted electronically, documents related to the order cycle are most commonly exchanged using EDI [3]. One could expect that the immediate improvements to speed, accuracy, and ordering costs by using EDI for the exchange of purchase orders, requisitions, and invoices would prompt their adoption. Thus,

> *H1. Increasing use of tactical information sharing is associated with supply chain relationship survival.*

Strategic information exchange, facilitated through information technology, lowers transaction costs between supply chain members. Research in the electronic exchange of information recognizes that not all information is the same. The outcomes of exchanging basic order information have been modeled in contrast to the outcome of sharing full information [1]. The exchange of full information is shown to provide a greater reduction of supply chain costs due to its impact on lead time and batch sizes. When information is exchanged to support strategic initiatives, more complex processes such as continuous replenishment programs can be developed. Thus,

> *H2. Increasing use of strategic information sharing is associated with supply chain relationship survival.*

Strategic information is likely to be more important in reducing transaction costs in a supply chain exchange. As modeled by Cachon and Fisher [1], information that supports the efficient flow of physical goods is of greater value to firms than information that merely speeds the exchange of order cycle information Thus,

> *H3. A larger strategic to tactical information sharing ratio is associated with supply chain relationship survival.*

METHODOLOGY

We test the three hypotheses in our study through an empirical examination of information exchange by manufacturing, wholesaling, and retailing firms. There are a total of 42 firms in our study with 24 manufacturers, six wholesalers, and twelve retailers. Data for this study is based on the analysis of archival supply chain transactions gathered from an electronically mediated trading partner network using EDI technology. EDI transaction summary data has been provided for all network transactions for a period of twenty-four consecutive months.

Our dependent variable of relationship survival is assessed through a longitudinal examination of the data. Each of the 42 firms in our study has a set of EDI transactions with its trading network in 2004 and 2005. If the trading partner exists in both years, then the relationship is considered to be one that "Survived." However, if the firm exists in the 2004 data and not in the 2005 data, then the relationship is put in the "Exited" category.

Our measures of tactical and strategic information exchange come from an examination of the volume and types of EDI transactions between supply chain partners. For the purposes of this study, EDI transaction types related to the order cycle have been identified as tactical. EDI transaction types that support additional interfirm functions have been identified as strategic.

We then test the three hypotheses by performing a t-test between the "Survived" and "Exited" groups for each of our three independent variables. A t-test draws on the mean value, standard deviation, and number of observations to examine whether or not there is a difference in means.

RESULTS

Table 1 provides a summary of the means analysis conducted to test the hypotheses. The first column identifies the participating firm as either a manufacturer (mfg), wholesaler (whslr), or retailer (retlr). The second and third identify the number of surviving and exiting trading partners respectively. The fourth through sixth columns show the average tactical volume for surviving and exiting trading partners. The seventh through ninth columns show the average strategic volume for surviving and exiting trading partners. The tenth through twelfth columns show the ratio of strategic volume to tactical volume for each group. The center column of each analysis identifies the direction of the statistical difference between the measures based on a t-test using the underlying variances for each group.

Hypothesis 1, increasing use of tactical information sharing is associated with supply chain relationship survival, is supported. The data in Table 1 provides support for this hypothesis. Since all of the statistically significant differences favor the surviving group, we can support H1 because the surviving relationships have a larger average volume of tactical information sharing. Of the 42 firms in our study, we found a statistically significant difference favoring the surviving relationships for 23 firms. The results are consistent for the manufacturers, wholesalers, and retailers in our study.

Table 1. Analysis of Information Exchange In Surviving and Non-Surviving Relationships

Firm	Survive N	Exit N	Tactical Volume Analysis			Strategic Volume Analysis			Ratio Analysis		
			Survive TactVol	Inequality Direction*	Exit TactVol	Survive StratVol	Inequality Direction*	Exit StratVol	Survive Ratio	Inequality Direction*	Exit Ratio
Mfg A	296	162	2,185	>	246	783	>	43	0.36	>	0.18
Mfg B	51	6	4,403		900	1,516		0	0.34	>	0.00
Mfg C	80	13	3,422	>	83	669	>	95	0.20		1.14
Mfg D	33	27	6,686	>	71	6,498	>	75	0.97		1.06
Mfg E	273	49	1,372	>	103	6,616	>	1,445	4.82	<	14.07
Mfg F	44	17	51,965		23,363	10,948		6,766	0.21		0.29
Mfg G	60	50	3,456	>	215	1,425	>	127	0.41		0.59
Mfg H	118	22	3,989	>	519	3,012	>	276	0.76		0.53
Mfg I	82	41	5,129		2,383	11	>	3	0.00	>	0.00
Mfg J	26	3	5,038		371	6,528		1,243	1.30		3.35
Mfg K	48	88	1,456		801	196		351	0.13	<	0.44
Mfg L	135	115	5,955	>	1,925	2,610	>	259	0.44	>	0.13
Mfg M	112	59	3,920		1,727	1,133		1,196	0.29	<	0.69
Mfg N	60	35	8,146	>	762	17,455	>	770	2.14	>	1.01
Mfg O	23	6	30,708		1,129	4,823		3,566	0.16	<	3.16
Mfg P	103	11	6,777		609	98	>	0	0.01	>	0.00
Mfg Q	661	47	992	>	206	1,834	>	744	1.85	<	3.61
Mfg R	68	22	8,285	>	427	1,476	>	50	0.18		0.12
Mfg S	66	4	1,536		360	44	>	10	0.03		0.03
Mfg T	26	10	2,116	>	533	310		333	0.15		0.62
Mfg U	97	26	4,365		1,992	2,156	>	525	0.49	>	0.26
Mfg V	28	6	5,056		63,901	400		427	0.08	>	0.01
Mfg W	51	6	4,403		900	1,516		0	0.34	>	0.00
Mfg X	6	19	1,529	>	62	973		55	0.64		0.89
Whlslr A	280	114	21,102	>	971	17,185	>	859	0.81		0.88
Whlslr B	241	98	10,228	>	1,113	9,006	>	807	0.88		0.72
Whlslr C	219	94	5,781		2,152	1,343		295	0.23	>	0.14
Whlslr D	510	79	4,375	>	328	1,241	>	144	0.28	<	0.44
Whlslr E	891	152	12,848		1,419	6,899	>	1,184	0.54	<	0.83
Whlslr F	55	11	1,180		9,494	194		7,865	0.16	<	0.83
Retlr A	371	109	27,706	>	3,911	11,010	>	529	0.40	>	0.14
Retlr B	478	53	3,126	>	609	893	>	233	0.29		0.38
Retlr C	130	109	3,945	>	887	1,212		699	0.31	<	0.79
Retlr D	1580	1203	31,332	>	9,305	3,851	>	873	0.12	>	0.09
Retlr E	235	77	16,834		6,081	8,323		5,084	0.49	<	0.84
Retlr F	69	49	1,655		67	922		21	0.56	>	0.32
Retlr G	15	68	4,662	>	293	256		6	0.05		0.02
Retlr H	4169	1999	4,242	>	644	1,428	>	253	0.34	<	0.39
Retlr I	22	368	6,309		571	710		213	0.11	<	0.37
Retlr J	250	100	3,015		1,288	577		529	0.19	<	0.41
Retlr K	1039	311	6,156	>	897	1,133	>	132	0.18	>	0.15
Retlr L	1243	436	1,900	>	170	112	>	0	0.06	>	0.00

*NOTE: Only statistically-significant differences are shown

Hypothesis 2, increasing use of strategic information sharing is associated with supply chain relationship survival, is also supported. The data in Table 1 provides support for this hypothesis. Of the 42 firms in our study, we found a statistically significant difference favoring the surviving relationships for 24 firms. The results are consistent for the manufacturers, wholesalers, and retailers in our study.

Hypothesis 3, a larger strategic to tactical information sharing ratio is associated with supply chain relationship survival, is not supported. Table 1 shows the average ratio of tactical to strategic volume for the surviving and exiting relationships. These results are inconsistent among the individual firms and industry groups, therefore, we so not show support for Hypothesis 3. The lack of support for this finding indicates that both types of information sharing may be important to supply chain relationship survival.

DISCUSSION

Greater tactical and strategic information sharing between supply chain partners is associated with trading partner survival. We find that increased information sharing increases the strength of a supply chain relationship as indicated by supply chain relationship survival.

Although Hypothesis 3 is not supported, the ratio of strategic to tactical information sharing among supply chain members appears to decrease as one moves downstream in the supply chain. An examination of the numbers in Table 1 shows an average ratio of strategic to tactical information sharing of 1.01 for manufacturers, 0.56 for wholesalers, and 0.29 for retailers which invites further investigation.

Although this paper makes several contributions, future research is still needed for additional insight. First, this paper does not examine the performance implications of supply chain relationship survival. It may be that firms use information sharing to continually sever relationships that are not improving their supply chain performance and continually adding to their set of supply chain trading partners. To this end, future research may consider the different levels of inventory turnover for the 42 firms in this sample and examine how their use and mix of information sharing affects supply chain performance. Furthermore, future research may consider examining information sharing between firms in a new supply chain relationship. Second, future research may consider more than just the volume of information sent between supply chain partners. Since we posit that strategic information is important, it would be valuable to examine the breadth and not just the depth of information exchange between surviving and exiting relationships. Finally, future research may want to consider constructs that cannot be collected through the archival data available to us. For example, marketing literature points to the importance of trust in mitigating the transaction risk. Future studies may use a survey approach to measure trust among supply chain relationships to understand the interaction of information sharing, trust, and supply chain relationship survival.

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RADIO FREQUENCY IDENTIFICATION (RFID) BETTER THAN ELECTRONIC DOCUMENT INTERCHANGE?

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ABSTRACT

Standards are important in supply chain management strategy. This paper compares and contrasts Electronic Data Interchange (EDI) and Radio Frequency Identification (RFID) technologies. It uses information from Microsoft's Xbox product line, which was originally managed with EDI. The most recent product, Xbox 360, is managed with RFID. The attributes of RFID implementations, and the benefits of RFID are discussed. This paper shows that organizations may realize intangible benefits in terms of business process improvements.

Introduction

Radio Frequency Identification (RFID) can be thought of as making bar codes dynamic. In effect, the individual units that one wishes to keep information about are marked in such a way that information about the unit is stored with the unit. With a bar code this information is static. That is the information - such as part number and part description - does not change. It is important to note that only static information can be stored on a bar code. One presumes that RFID shares attributes bar codes in that the same mark (tag) would be used throughout the supply chain. Thus like a bar code - the tag would pass from one company to another and hopefully provide utility to all companies.

RFID implementations must include middleware that can take data feeds from a reader, aggregate the data, do data smoothing and filtering, and then store the data. This layer also provides a level of intelligence by interpreting the data in basic ways, such as determining which applications to route data to. These applications may exist within or external to the organization.

The improvement that RFID provides is not only more convenient access to the stored information, but also the potential for dynamic information. An example of this dynamic information would be physical location, and while this is generally not achieved by storing location information - rather by using physical proximity to an antenna - it is a powerful example of what dynamic information could to for the supply chain.

RFID Benefits

Among the tangible benefits an RFID implementation can provide are those associated with managing product quality control and creating efficiencies within the supply chain. RFID eliminates the need to re-scan products constantly to verify inventory status and keep product information complete and up-to-date. In the long run, RFID systems could automate the scanning process completely, replacing manual scanning. The labor savings alone could justify the cost of the system, and large consumer products and manufacturing companies would gain better tracking and inventory location capabilities, from the manufacturing plant to the store shelves.

Make no mistake the benefits from RFID are such that large investment has already taken place in this area. The most widely discussed example is Wal-Mart. And it is from that experience that four tangible benefits from RFID are clear. These include fewer "stock-outs"; faster "replenishment"; fewer "manual orders"; and less "excess inventory"[3]. Simply put fewer "stock-outs" means less lost sales due to lack of goods. Faster "replenishment" means less lost sales for the time period that the supply of goods is replaced due to the fact that this time period has been shortened. Fewer "manual orders" means less guessing about the amount of goods to have on hand for sale - thus either preventing lost sales due to lack of goods, or having goods that will not sell. Less "excess inventory" is simply preventing the situation where you have goods that will not sell.

It is important to note that these benefits have been demonstrated at Wal-Mart. Further, these same benefits can occur throughout the supply chain.

Three Information Transitions

While it is clear that RFID is beneficial, and practical, it is also important to be very clear about the attributes of RFID as it has been implemented thus far. It is fair to note that in most publicly discussed implementations of RFID, it is applied to moving pallets and crates from a production warehouse to one or more distribution warehouses. It is also fair to note that each of these implementations have important differences rather than similarities - which is not a good environment for building standards. For example, Wal-Mart is a very large implementation - which makes the economy of scale for most of the goods they handle very much within their reach, however, it makes a poor example of what should be done in every implementation of RFID. Another unique example that has been discussed is a company that sells canned fruits and vegetables. The cans are made of metal, which confounds the transmission of radio frequencies, and the can contain liquid which reduces the propagation of radio waves. This is a very different situation from Wal-Mart - and also provides a poor example of what should be done for every implementation of RFID. However, it does provide an important example to notice for the way RFID is currently discussed. The reason that one would cover the implementation of RFID at a company that cans fruits and vegetables is that the implementation is unusual. In essence, the coverage of RFID will tend to focus on unusual implementation of RFID - largely due to the idea that these are interesting and also with a subtext that RFID is arriving because it is working in these odd environments.

The result is that almost no one notices that these are implementation that do have similar attributes. They typically involve two companies, and movement of goods from a production facility to a distribution facility.

There are two much larger domains that can and will benefit from RFID. These are the production process prior to the production warehouse, and the distribution process after the the distribution warehouse. Further, significant problems in these domains have already been discovered. On the production side the same hot, hazardous, and heavy conditions that cause a need for investment in automation will impact the use of radio in these environments. On the distribution side the often discussed privacy concerns of the customer make this environment unique from the others with a special focus on information and information flow, rather than technology. These issues should be an important part of the concept of operations for a full supply chain RFID - otherwise - there must be three different types of RFID - production, distribution, and sales - which will be implements over a long time frame due to the reduced economies of scale for the technology.

In effect, there are three domains that will use RFID and they have different demands from RFID. Thus, the data fields are most likely to pass through this entire process, but not organizational forms.

EDI

EDI predates RFID. Concepts in EDI can be traced back to the Berlin Airlift (1948) and attempts at standardized data interchange in the United State's transportation industry (1968)[1]. A major difference between EDI and bar codes that is important to consider is the treatment of information. Bar codes carry a small set of data fields that are generally useful to the entire supply chain. So, while the data structure is standardized the amount of data is so small that the ability to focus on the data fields needed at any point in the supply chain is not hampered. EDI does not share this attribute. A focus of EDI is documents and in fact some refer to EDI as Electronic Document Interchange. This is in fact a part of EDI's architecture. The focus on records rather than fields results in the movement of larger amounts of data – some of which may not be useful in much of the supply chain. Thus, EDI has not been successful with the information transitions noted above.

The Xbox Experience

An example of a supply chain that has been supported by EDI and RFID is the Xbox. Production of the Xbox was originally supported by EDI. The process was point to point, and the "documents" were periodically batch processed. Given the emphasis on Documents and Forms this would be the expected process.

For the Xbox 360 it appears Microsoft wanted to include their SQL Server and XML for support of the production process. This is accomplished using RosettaNet which promotes messaging standards for bar codes and RFID.

The benefits from this transition include increase in on-time deliveries; enhanced visibility of problems; reduction of inventory loss; increased responsiveness in outsourced manufacturing[2]. Notice the similarity to Wal-Mart's experience with RFID.

Conclusion

The real lesson demonstrated by examining these implementations is about focus. The EDI efforts for over 50 years have provided a clear and important goal. This goal is the movement of clear and reliable information along the supply chain. While this goal is easy to state, clear and reliable information does not occur when data is constantly reentered or when data is to remote from the unit about which the data is collected. RFID may be able to address these problems by keeping data coupled with the unit, by avoiding batch processing, and data reentry.

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MODIFIED DEA MODELS FOR SUPPLIER SELECTION COORDINATING BETWEEN SUPPLIERS AND A BUYER

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ABSTRACT

Selecting supplier is a complicated but essential decision-making process that requires considering multiple attributes that significantly influence competitive advantages of buyer and finally determine the success of the whole supply chain. In the context of supply chain coordination, we propose a modified DEA model that focuses on both realization of the most efficient supply chain and maximization of efficiency of the buyer according to different strategies. Finally, the paper provides a numerical example.

Keywords: Supplier selection, Data envelopment analysis

INTRODUCTION

Choosing a suitable supplier improves effectiveness and efficiency of supply chain. Recently, with more and more awareness of the importance of these activities, purchasing managers are largely price-oriented, especially in business-to-business transactions [10]. Those price-driven transactions between buyers and sellers have two obvious shortcomings. One of them is ignoring other factors such as qualitative measures. All of these qualitative measures are so important that they determine the success of the buyer. Without the guarantee of delivery on-time for the material or any other sourcing, the buyer cannot ensure the service level. Similarly, the poor quality of sourcing would be fatal to the improvement of the quality of the final product. Recently, the buyers are coming to conduct a full evaluation on a variety of attributes including quality, delivery and other dimensions. Some mathematical programming models are helpful, but the complexity of computation obstracts the application. Purchasing managers need more handful tool such as DEA.

The second shortcoming of price-driven purchasing strategy leads to low efficient of the whole supply chain. Willcock[1] investigates three-quarters of "winner's curse" outsourcing deals and finds those the provider makes no profit all result in a bad experience for the customer. Why this happens? Usually, the buyer would expect the supplier to offer high quality with lower pricing charge. Extremely, some bidding mechanism reduces the supplier's margin so greatly that the supplier really has nonpositive profit to sustain a long-term

development. The lower efficiency of the supplier must cause the lower-down of the whole supply chain.

As a result, Willcock[1] suggests companies should look at supplier's capability to respond to day-to-day operational needs, its ability to deliver radically improved services in terms of cost and quality and its willingness to align itself with the company's values, goals and needs. That is same to say, the efficiency of supplier needs to be taken into consideration. However, it is obvious that the efficiency of supplier has no direct effect on the efficiency of the buyer. The only intermedium involved is the efficiency of the supply chain. In long run, the efficient performance of the supplier leads to the improvement of the efficiency of the whole supply chain. In stead, the short-sight purchasing action leads to the fragile status of the supply chain. The supply chain is subject to high risks and cannot last for a long time. The buyers' hope of building long-term partner relationship is impossible. As a result, some scientific selection methodologies and bidding systems are in demand. One of the most efficient ways is to measure efficiency. Consequently, DEA is a good measure in that it is straightforward and tractable.

LITERATURE REVIEW

The development of analytical models for supplier selection has received significant attention in the literature. The technical methodologies include analytical hierarchy process, principal components analysis, statistical analysis, neural nets. Other mathematical programming methods like linear programming, mixed integer programming and goal programming are also widely used in this field.

Data Envelopment Analysis (DEA) is introduced by Charnes, Cooper, and Rhodes[2]. It is a data-oriented approach to evaluate the performance of several Decision Making Units (DMUs) that convert multiple inputs into multiple outputs. The method is used to study benchmarks and to compare the efficiency of different organization performance. In the area of supplier selection, we have only identified several papers that utilize DEA models. As a pioneer work, Weber et al's paper[7 firstly applies the DEA method into supplier evaluation and selection, companied with parallel coordinates representation methods. Further, Weber et al[8] combine DEA and multi-objectives programming to solve supplier selection problem. Both of the above DEA models treat price as the input and other factors like delivery performance (the percentage of ordered units late) and quality performance (the percentage of units rejected) as outputs.

Talluri[6] extends the above methodologies by including the target that is composed by the largest outputs and the smallest inputs among the suppliers. The new game model minimizes the efficiency ratio for each DMU against the target. Then a 0-1 integer program model could select an optimal set of bids that satisfies the demand requirement and the minimum order condition. Furthermore, Zhu[10] maximizes the efficiency ratio for each DMU according to the target and compares the results with those from Talluri's paper. All the above papers just

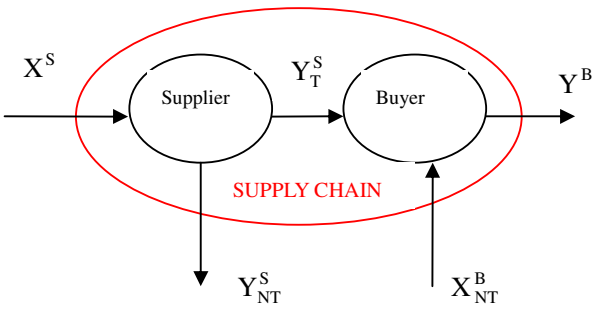
regard purchasing as a one-shot activity. More exactly, the efficiency they are talking about is just of the efficiency of the purchasing itself. The long-run trade-off cannot be fully embodied in the above methods. They totally ignore the efficiency of the supply chain.

Liang et al. [5] use DEA models to evaluate supply chain efficiency. In the leader-follower's model, the basic idea is to evaluate the leader's efficiency firstly, and then to maximize the efficiency of the follower with two constraints: 1) the leader's efficiency remains at the optimal level 2) the new weights of intermediates would be proportionate to the calculated one in the leader's model. Based on the corporative case, another model optimizes the average values of the efficiencies of the supplier and that of the buyer directly. Another paper by Chen et al.[3] discusses the existence of Nash Equilibrium in the game of efficiency where the Pareto optimal efficiency can be reached so that no one can increase his own efficiency without sacrificing the other's efficiency. Both of these two papers distinguish our paper in two aspects. Firstly, they stand on the third person's perspective to evaluate the performance of existent supply chain while in our paper the buyer needs to find the best supplier to optimize the efficiency of the whole supply chain. Secondly, the above two papers ignore the fact that the outputs of the supplier might serve other buyers. The "Keiretsu" case (one-to-one relationship) is a special case that cannot be applied into the general case. Usually, each supplier needs to provide a single product or multiple products to several buyers. Investments or inputs of suppliers could have spillover effects on other buyers. It indirectly influences the evaluation of the current buyer. Our selection model investigates the effects.

Here we propose a new model that maximizes the efficiency of the supply chain ensuring certain efficiency that the buyer can get. As the general DEA model [4], our model is easily applicable in practice. In addition, compared with the above DEA models, our model has distinct advantages over others. 1) It is closer to the general case and practice; 2) The efficiency of coordination can be taken care at the beginning of supplier selection; 3) Buyer, a single decision maker, determines the weight and evaluates the efficiency supply chain with a new supplier involved; 4) the intermediate inputs and outputs are concerned.

MODEL STRUCTURE

FIGURE 1 SUPPLY CHAIN AND INDIVIDUAL INPUTS AND OUTPUTS STRUCTURE



We model the following scenario. A buyer needs to select among several suppliers. All the suppliers must report all their true information related to their inputs and outputs. As to each pair of a supplier and the buyer, the relationship of inputs and outputs for each individuals and the whole supply chain is described in Figure 1, where Y^B is the output vector of the buyer, and X_{NT}^B is the input vector that the buyer needs to afford. Y_T^S is not another input vector for the buyer but also output from the supplier. For the supplier, X^S is an input vector, along with Y_{NT}^S being output vector without transferring to the buyer. U^T,W^T,V^T,Q^T and P^T are the weight vectors for each of the above dimensions respectively. Then, we can develop the supply chain efficiency oriented model as the below:

$$\max \quad \frac{U^T Y^B + P^T Y_{NT}^{SO}}{V^T X_{NT}^B + Q^T X^{SO}}$$

$$s.t. \quad \frac{U^T Y^B + P^T Y_{NT}^{Sj}}{V^T X_{NT}^B + Q^T X^{Sj}} \le 1 \quad \textit{for all } j=1,\ldots,n$$

$$\frac{U^T Y^B}{V^T X_{NT}^B + W^T Y_T^{SO}} = E_B^0$$

$$\frac{U^T Y^B}{V^T X_{NT}^B + W^T Y_T^{Sj}} \le E_B^0 \quad \textit{for all } j=1,\ldots,n,$$

$$U^T, V^T, W^T, P^T, Q^T \ge 0$$

In the contest of supply chain coordination, the buyer wants to maximize the efficiency of the whole supply chain. The first set of the constraints means the efficiency of the supply chain with other suppliers calculated by the optimal weights for the current supplier should not be better than that for the current one. The second row of constraints says that the optimization here needs to subject to the guarantee the expected supply chain efficiency specified by the buyer himself. The last set of constraints makes sure that all supply chain efficiency with other suppliers must be less than that for the current one. The above nonlinear model could be transferred to a linear model that is easy to solve by any handful solver such as Lindo:

$$\max \quad U^T Y^B + P^T Y_{NT}^{SO}$$

$$s.t. \quad V^T X_{NT}^B + Q^T X^{SO} = 1$$

$$V^T X_{NT}^B + Q^T X^{SO} - U^T Y^B - P^T Y_{NT}^{SO} \ge 0 \quad \textit{for all } j=1,\ldots,n$$

$$E_B^0 * (V^T X_{NT}^B + W^T Y_T^{SO}) - U^T Y^B = 0$$

$$V^T X_{NT}^B + W^T Y_T^{SO} = 1$$

$$E_B^0 * (V^T X_{NT}^B + W^T Y_T^{SO}) - U^T Y^B \ge 0 \quad \textit{for all } j=1,\ldots,n,$$

$$U^T, V^T, W^T, P^T, Q^T \ge 0$$

NUMERICAL EXAMPLE AND CONCLUSION

TABLE 1 DATA

# SUPPLIER	SUPPLIER						BUYER		
	INPUT			OUTPUT	TRANSFERING PART		INPUT	OUTPUT	
(VARIBLES IN OUR PAPER)	XS1	XS2	XS3	YSNT1	YST1	YST2	XBNT1	YB1	YB2
(VARIABLE NAME IN REFERENCE PAPER)	XS1	XS2	XS3	\	YS1	YS2	XM1	YM1	YM2
(weight)	(q1)	(q2)	(q3)	(p1)	(w1)	(w2)	(v1)	(u1)	(u2)
1	9	50	1	6	20	10	8	100	25
2	10	40	4	20	10	15	8	100	25
3	9	30	3	15	8	20	8	100	25
4	8	25	1	4	20	20	8	100	25
5	10	40	5	18	15	20	8	100	25
6	7	35	2	29	35	10	8	100	25
7	7	30	3	11	10	25	8	100	25
8	12	40	4	20	20	25	8	100	25
9	9	25	2	11	10	10	8	100	25
10	10	50	1	19	20	15	8	100	25

We illustrate the above model with ten supplier candidacies (DMUs) and a single buyer given in the above table Table 1. The buyer will determine which supplier he will choose. We adjust the data from the article of Chen to include the spillover effect Y^{S}_{NT1} in the context of supply selection. Based on our assumption, the decision maker--the buyer knows all inputs and outputs from the supplier and himself. According our model above, the buyer needs to specify a desirable level of efficiency. As the ideal situation, the value of $E_{SC}{}^{0}$ is set as 1.

TABLE 2 RESULTS

	1	2	3	4	5	6	7	8	9	10
EFFICIENCY FOR THE BUYER	1	1	1	1	1	1	1	1	1	1
EFFICIENCY FOR THE SUPPLIER CHAIN	-	-	0.992286	-	-	-	-	-	1	-
U1	-	-	0.0095229	-	-	-	-	-	0.007364	-
U2	-	-	0.001	-	-	-	-	-	0.001	-
W1	-	-	0.001	-	-	-	-	-	0.021689	-
W2	-	-	0.0017143	-	-	-	-	-	0.001	-
V1	-	-	0.0021429	-	-	-	-	-	0.03924	-
Q1	-	-	0.001	-	-	-	-	-	0.001	-
Q2	-	-	0.114661	-	-	-	-	-	0.001	-
Q3	-	-	0.005	-	-	-	-	-	0.001	-
P1	-	-	0.001	-	-	-	-	-	0.074342	-

After calculation, we get the above results in Table 2. The best supplier for the buyer is the 9th supplier. The supplier gets the largest efficiency for the supply chain with the value as 1. The 3rd supplier is very close to optimal value. She can ensure the efficiency of the buyer as 1, but the maximum efficiency for the supply chain is approximate 1. The sign "-" means that there is no feasible solution for the current DMU. Except the 9th supplier and the 3rd supplier, the other supplier cannot coordinate the supply chain or meet the requirement of the level of the efficiency as 1 for the buyer.

Our new model is easy to use and more match to the reality, so it has a very strong theoretical and practical significance. In our further research, we should consider the incentives for the suppliers to provide all information of input and output to the buyer. The information sharing is critical to the coordination of the supply chain and the measure of the efficiency. Meanwhile, the necessary measures to avoid moral hazard behavior from the suppliers are more than expected. The setting of the weights in modified DEA model need to give a good guide for the supplier well behaved.

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INTEGRATED PRODUCTION AND RECOVERY PLANNING IN CLOSED-LOOP SUPPLY CHAINS

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ABSTRACT

Recovery of used products and their remanufacturing into new ones is gaining justifiable popularity among many companies worldwide. This process requires two supply chain flows: a reverse flow for used product acquisition, logistics, disassembly, recovery, and disposition; and a forward flow for moving new and remanufactured products from the point of production to the point of consumption. Forward and reverse supply chains form a closed loop when they are managed in an integrated and coordinated way. This paper presents a multi-period cost-minimization model for integrated production distribution and recovery planning in closed-loop supply chains.

Keywords: Closed-Loop Supply Chains, Product Recovery, Reverse Logistics

INTRODUCTION

Increasingly, manufacturers are establishing production and distribution systems that enable remanufacturing of used products in parallel with the manufacturing of new ones (Savaskan et al. 2004). Remanufactured products are generally upgraded to the quality standards of new products so that they can be sold as new products. The production and distribution systems which combine manufacturing and remanufacturing are referred to as closed-loop supply chains.

Closed-loop supply chains differ from traditional supply chains in many aspects. In a traditional supply chain the product is moved forward, and the customer is typically at the end of the chain. However, a closed-loop supply chain includes not only the forward processes, but also the reverse activities of product return and recovery. These activities include: acquisition of used products from end-users and their transportation to disassembly sites, recovery and storage of reusable units, disposition of non-reusable units, and remanufacturing of reusable units.

A growing amount of operations management research addresses reverse logistics issues. A comprehensive literature review can be found in Fleischmann et al. (1997) and Guide et al. (2000). Reverse logistics research may be classified into three main areas: (1) reverse distribution planning (Pohlen and Harris II, 1992; Jahre, 1995), (2) inventory control of return flows (Schrady, 1967; Mabini and Gelders, 1991; Barros et al., 1998), and (3) production planning with reuse of parts and materials (Johnson and Wang, 1995; Van der Laan and Salomon, 1997). It is noteworthy that this literature appears to be focused mainly on optimization and inventory control of return flows. Studies addressing production and distribution planning in closed-loop systems which combine manufacturing and remanufacturing are rare.

Remanufacturing can be carried out by a local manufacturer or an original equipment manufacturer (Pranab and Harry 2001). In this paper we consider the latter case wherein the manufacturer remanufactures products from returned cores and other major components in parallel with the manufacturing of new ones in the same facilities. In this environment, remanufacturing activities have to be integrated with manufacturing planning decisions so that material requirements, inventory levels, and capacity needs over the various stages of production, disassembly, recovery, and disposition can be coordinated in the most economical way.

The objective of the paper is to formulate a comprehensive multi-period cost-minimization integrated production and recovery planning model that provides unambiguous answers to such important and complex questions as: In which plant and in what quantity should the new and remanufactured products be produced in every time period of the planning horizon? Which plants should service which market's product demand, and in what quantity in every period? How many units of the finished product are held in inventory in each plant in every period? How many used products are to be collected by every retailer in every period? How many used products are to be disassembled by each disassembly center in every time period? How many recovered (recycled) units should each disassembly center ship to each plant in every time period? How many recycled units should be held in inventory at each disassembly center in every period? In which disposal site, and in what quantity per time period should non-recoverable units be disposed of?

MODEL DEVELOPMENT

The proposed integrated production and recovery planning model follows the closed loop network structure shown in Fig. 1. The supply chain includes two types of flows: forward and reverse flows. Forward flows represent transportation of new and remanufactured products from plants to retailers. The reverse flows represent: (1) transportation of used products from retailers to disassembly centers, (2) transportation of used non-recoverable units from disassembly centers to disposal sites, and (3) transportation of recycled units from disassembly centers to plants.

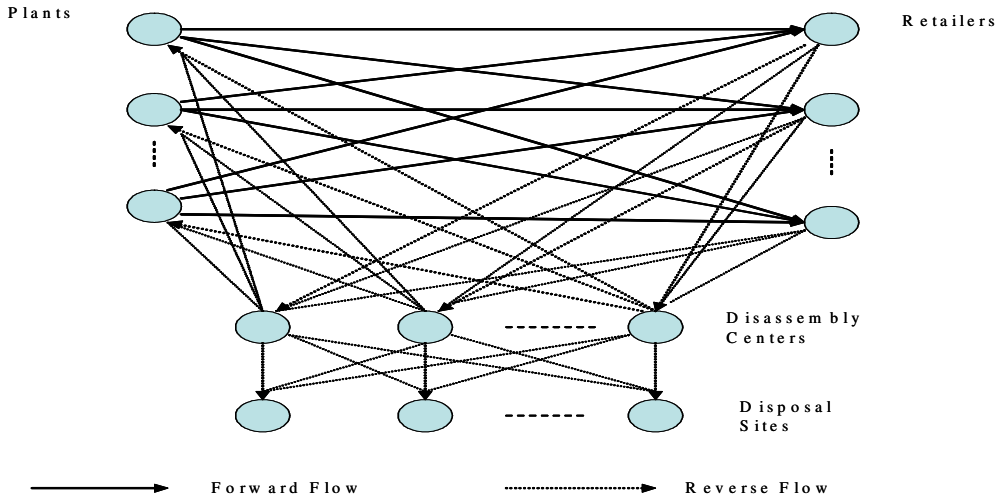

Fig. 1 Closed-Loop Network

Assumptions

In order to facilitate the formulation of the model, the following ten assumptions are postulated:

1. The supply chain facilities (plants, retailers, disassembly centers, and disposal sites), already exist.
2. The new and remanufactured products share the same logistics mode for transportation from plants to retailers.
3. Product demand at retailers is know.
4. The retailers are responsible for collecting used products from consumers.
5. There is a given return ratio, reflecting the proportion of used products returned by consumers.
6. Plant production capacities, retailer used product collection capacities, and disassembly center capacities are known.
7. The maximum recoverable ratio of used products at disassembly centers is known.
8. Inventory of finished products is held at the plants.
9. Inventory of recovered (recycled) units is held at the disassembly centers.
10. Disposal sites have unlimited capacities.

Notation

We use the following notation to formulate the model.

Primary Sets and indices

$I =$ Set of plants, $i \in I$;

$K =$ Set of disassembly centers, $k \in K$;

$J =$ Set of retailers, $j \in J$;

$M =$ Set of disposal sites, $m \in M$;

$T =$ Set of time periods, $t \in T$;

Supply/Demand Data

$D_{jt} =$ Product demand at retailer j during period t;

$S_{it} =$ Production capacity at plant i during period t;

$S_{jt} =$ Used product collection capacity at retailer j during period t;

$S_{kt} =$ Product disassembly capacity at center k during period t;

$\gamma =$ Product return ratio;

$\lambda =$ Product recovery ratio during disassembly;

Cost Data

$F_{it} =$ Fixed production cost at plant i during period t;

$C_{it} =$ Variable production cost of a unit out of new (non-recycled) material, at plant i during period t;

$C_{kit} =$ Variable production cost of a unit at plant i out of recycled materials sourced from processing center k during period t; This cost includes production, transportation and material cost;

C_{jkt} = Variable cost of collecting a used unit from retailer *j*, shipping it to and disassembling it at center *k* during period *t*;

C_{kmt} = Cost of transporting a non-recoverable unit from center *k* and disposing it at site *m* during period *t*;

H_{it} = Holding cost of a new unit in inventory at plant *i* throughout period *t*;

H_{kt} = Holding cost of a unit of recycled material in inventory at center *k* throughout period *t*;

T_{ijt} = Unit transportation cost of a product from plant *i* to retailer *j* during period *t*;

Variables

X_{ijt} = Units of product shipped from plant *i* to retailer *j* in period *t*;

U_{jkt} = Units of used product collected by retailer *j* and shipped to center *k* in period *t*;

R_{kit} = Units of new product produced in plant *i* out of recycled material sourced from center *k* in period *t*;

W_{kmt} = Units of used product processed at center *k* and disposed of at site *m* in period *t*;

Y_{it} = Units produced at plant *i* in period *t* out of new (not recycled) material;

I_{it} = Units of product held in inventory at plant *i* at the end of period *t*;

V_{kt} = Units of recycled material held in inventory at center *k* at the end of period *t*;

$$Z_{it} = \begin{cases} 1, \text{ if product is produced in plant } i \text{ during period } t; \\ 0, \text{ otherwise.} \end{cases}$$

Constraints

$$Y_{it} + \sum_{k \in K} R_{kit} \le S_{it} Z_{it}, \qquad i \in I, t \in T; \qquad (2)$$

Equation (2) specifies that the combined number of new and remanufactured units produced at plant *i* during period *t* must be less than or equal to that plant capacity if the product is produced in such a plant at that time period; and equal to zero otherwise.

$$\sum_{i \in I} X_{ijt} = D_{jt}, \qquad j \in J, t \in T; \qquad (3)$$

Constraint set (2) ensures that product demand at each retailer and in every time period is met through quantities shipped from the various plants.

$$I_{i,t-1} + Y_{it} + \sum_{k \in K} R_{kit} = \sum_{j \in J} X_{ijt} + I_{it}, \qquad i \in I, t \in T; \qquad (4)$$

Equation (4) ensures product flow balance between inventory, production, and shipment of finished products at each plant and in every time period. Inventory may be carried to provide better customer service or to satisfy forecasted demand that exceed production capacities in future time periods.

$$V_{k,t-1} + \lambda \sum_{j \in J} U_{jkt} = \sum_{i \in I} R_{kit} + V_{kt}, \qquad k \in K, t \in T; \qquad (5)$$

Constraint set (5) ensures product flow balance between inventory, processing, and shipment of recycled units at each disassembly center and in every time period.

$$\sum_{k\in K} U_{jkt} \le S_{jt}, \qquad j \in J, t \in T; \qquad (6)$$

Equation (6) requires that the number of used units collected by each retailer in every period to be less than its maximum collection capacity.

$$\sum_{j\in J} U_{jkt} \le S_{kt}, \qquad k \in K, t \in T; \qquad (7)$$

Constraint set (7) requires that the number of units processed by each disassembly center in each period to be less than the maximum capacity of that center.

$$\sum_{j\in J}\sum_{k\in K} U_{jkt} \ge \gamma \sum_{j\in J} D_{jt}, \qquad t \in T; \qquad (8)$$

Constraint set (8) specifies the relationship between the number of units processed at all disassembly centers in a given time period and the number of used units returned by consumers during that time period. This constraint states that a minimum of γ percent of total demand of new product in each period is expected to be returned as used product in that time period.

$$\sum_{m\in M} W_{kmt} = (1-\lambda)\sum_{j\in J} U_{jkt}, \qquad k \in K, t \in T; \qquad (9)$$

Constraint set (9) represents the number of non-recoverable units transported from a given disassembly center to all disposal sites.

Objective Function

$$\text{Min} \sum_{t\in T}[\sum_{i\in I}(F_{it}Z_{it} + C_{it}Y_{it} + H_{it}I_{it}) + \sum_{i\in I}\sum_{k\in K} C_{kit}R_{kit} + \sum_{k\in K} H_{kt}V_{kt} + \sum_{j\in J}\sum_{k\in K} C_{jkt}U_{jkt} + \sum_{k\in K}\sum_{m\in M} C_{kmt}W_{kmt} + \sum_{i\in I}\sum_{j\in J} T_{ijt}X_{ijt}] \qquad (1)$$

Objective function (1) minimizes the total multi-period cost of production, collection, disassembly, disposal, inventory, and transportation of the closed-loop system. The components of the objective function may be described as follows:

Production cost over the entire planning horizon $= \sum_{t\in T}\sum_{i\in I}(F_{it}Z_{it} + C_{it}Y_{it} + \sum_{k\in K} C_{kit}R_{kit})$.

Inventory costs at plants and processing centers $= \sum_{t\in T}\sum_{i\in I} H_{it}I_{it} + \sum_{t\in T}\sum_{k\in K} H_{kt}V_{kt}$.

Collection, transportation, and processing costs of used units $= \sum_{t\in T}\sum_{j\in J}\sum_{k\in K} C_{jkt}U_{jkt}$.

Disposal and transportation costs of non-recyclable units $= \sum_{t\in T}\sum_{k\in K}\sum_{m\in M} C_{kmt}W_{kmt}$.

Transportation cost of new units from plants to retailers $= \sum_{t\in T}\sum_{i\in I}\sum_{j\in J} T_{ijt}X_{ijt}$.

Our mixed integer programming model can now be rewritten as follows.

$$\text{Min} \sum_{t\in T}[\sum_{i\in I}(F_{it}Z_{it}+C_{it}Y_{it}+H_{it}I_{it})+\sum_{i\in I}\sum_{k\in K}C_{kit}R_{kit}+\sum_{k\in K}H_{kt}V_{kt}+$$
$$\sum_{j\in J}\sum_{k\in K}C_{jkt}U_{jkt}+\sum_{k\in K}\sum_{m\in M}C_{kmt}W_{kmt}+\sum_{i\in I}\sum_{j\in J}T_{ijt}X_{ijt}] \quad (1)$$

Subject to:

$$Y_{it}+\sum_{k\in K}R_{kit}\le S_{it}Z_{it}, \qquad i\in I, t\in T; \quad (2)$$

$$\sum_{i\in I}X_{ijt}=D_{jt}, \qquad j\in J, t\in T; \quad (3)$$

$$I_{i,t-1}+Y_{it}+\sum_{k\in K}R_{kit}=\sum_{j\in J}X_{ijt}+I_{it}, \qquad i\in I, t\in T; \quad (4)$$

$$V_{k,t-1}+\lambda\sum_{j\in J}U_{jkt}=\sum_{i\in I}R_{kit}+V_{kt}, \qquad k\in K, t\in T; \quad (5)$$

$$\sum_{k\in K}U_{jkt}\le S_{jt}, \qquad j\in J, t\in T; \quad (6)$$

$$\sum_{j\in J}U_{jkt}\le S_{kt}, \qquad k\in K, t\in T; \quad (7)$$

$$\sum_{j\in J}\sum_{k\in K}U_{jkt}\ge\gamma\sum_{j\in J}D_{jt}, \qquad t\in T; \quad (8)$$

$$\sum_{m\in M}W_{kmt}=(1-\lambda)\sum_{j\in J}U_{jkt}, \qquad k\in K, t\in T; \quad (9)$$

$$I_{it},Y_{it}\ge 0,\ Z_{it}=\{0,1\}, \qquad i\in I, t\in T; \quad (10)$$

$$X_{ijt},U_{jkt},R_{kit},W_{kmt},V_{kt}\ge 0, \qquad i\in I, j\in J, k\in K, m\in M, t\in T; \quad (11)$$

CONCLUSION

This paper presented a cost-minimization model for integrated production and recovery planning in closed-loop supply chains with product remanufacturing. The proposed model has two distinctive features. First, new and remanufactured products are treated jointly. As a result, remanufacturing decisions are integrated with manufacturing planning decisions so that material requirements, inventory levels, and capacity needs over the various stages of production, disassembly, recovery, and disposition can be coordinated in the most economical way. Second, the recoverable ratio which represents the quality of the used product is taken explicitly into consideration. This feature will enable the decision maker to estimate economic cost and feasibility of remanufacturing as a function of a varying recoverable ratio. A computational experiment of this model is being undertaken and its results will be reported at a later date.

References available upon request from the author.

IMPROVED MEASURE OF SUPPLY CHAIN INTEGRATION

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ABSTRACT

The importance of Supply Chain Integration (SCI) is well established in the literature. However, the areas where integration needs to be established among supply chain partners are not clearly conceptualized and defined in the prior literature. The objective of this study is to develop and validate a better measurement model of Supply Chain Integration. In this paper we present a richer SCI construct that uses multiple perspectives based on literature from fields such as operations management, strategic management, and inter-organizational relationship management.

(Keywords: Supply Chain Integration, Supply Chain Management, Empirical Research, Survey)

INTRODUCTION

Many practitioners and researchers believe that integration of processes at partner firms is critical for improving the performance of a supply chain. They argue that integrated supply chains are likely to perform better in terms of less inventory, better customer service, lower cost, shorter new product development time, improved information and material flows, and ultimately superior financial results. Research to verify these arguments could benefit from a more satisfactory way to measure supply chain integration than has been presented before.

Supply Chain Integration (SCI) has been conceptualized and measured in different ways in different management disciplines, most of them unsatisfactory for the following reasons - First, most existing studies in the operations management stream measure SCI as a composite of internal integration and external integration with suppliers and customers but use only one measurement item to validate each dimension. It is well established that psychometric properties of any construct will likely be improved by use of appropriate multiple measurement items. Improving the way of measuring the supply chain integration is likely to allow determination of the effects of integration in a more reliable and valid fashion. Second, use of a single measurement item to validate each dimension of supply chain integration fails to account for the entire gamut of processes that supply chain partners may integrate to achieve true integration. Identifying the areas where supply chain partners could jointly undertake integration initiatives would guide managers to work on those areas in order to reap the benefits of integration. Finally, differences in conceptualization of the core construct of SCI in prior studies make it difficult to compare results and draw generalized conclusions.

The objective of this study is to develop and validate a better measurement model of Supply Chain Integration. In this paper we present a richer SCI construct that uses multiple perspectives based on literature from fields such as operations management, strategic management, and inter-organizational relationship management. Specifically, we will present a model of supply chain integration as a second order factor comprised of three first order factors: external integration with supplier, external integration with customer, and internal integration.

In Section 2, we review the literature to highlight how Supply Chain Integration is conceptualized and measured in each of the various streams of management research. Section 3 describes the empirical study conducted to test and validate the construct. In Section 4 we present results of tests to confirm construct validity. The paper concludes with a discussion of the results and implications for future research.

CONCEPTUALIZATION OF SUPPLY CHAIN INTEGRATION FROM PRIOR RESEARCH

Different streams of management literature have conceptualized supply chain integration in different ways. For example, the operations management literature defines "supply chain integration". The inter-organizational relationship literature and the strategy literature define closely related terms: "relational governance", "collaboration", and "strategic partnerships".

The operations management literature has provided interesting insights into the notion of integration. Many studies in operations management literature recognized that supply chain integration comprises of internal integration within a firm and external integration with down stream (customers) and upstream (suppliers) supply chain partners. The two exceptions seem to be Armistead and Mapes (1993) and Pagell (2004). Both these works focus on aspects of internal integration. Armistead and Mapes (1993) measure integration using a composite index based on the extent of shared ownership of master production schedule, level of adherence to manufacturing plans, and use of job titles that span traditional functions, Pagell (2004), however, focuses on identifying facilitators and inhibiters of internal integration across operations, purchasing and logistics functions. He measures level of internal integration by the time spent by operations, logistics and purchasing functions in interacting and collaborating to arrive at mutually acceptable outcomes.

Stevens (1990), Anderson and Lee (2000), and Aryee et al. (2005) provide conceptual frameworks that attempt to describe the phased evolution of integration in supply chains. All these frameworks emphasize that true and full integration is achieved only when business processes spanning multiple partners are integrated. None of these three frameworks has yet been empirically validated. Also, none of the frameworks highlights the areas where internal and external integration are possible. Stevens (1990) defined an integrated supply chain as a method for managing material flow from strategic, tactical and operational perspectives as firms go through four stages in series. Starting from a baseline stage, firms progress through functional integration stage, internal integration stage, and finally the external integration stage. Anderson and Lee (2000) propose a framework which claims that firms go through three phases of integration – starting with optimization within a business function followed by internal integration between business functions and culminating in external synchronization and coordination across supply chain participants (business units with their suppliers and customers). They argue that capabilities and benefits increase as firm progress from the optimization stage to external synchronization and coordination stage. Recently, Aryee et al. (2005) propose a somewhat similar framework for supply chain integration that uses a maturity scale to identify

two stages – internal integration (within the firm) and external coordination (firm with its suppliers and customers).

We found two recent studies that focus only on external integration. Cousins and Megnuc (2006) consider external integration with suppliers and Bagchi et al. (2005) consider external integration with suppliers and customers. Even though they considered a few processes such as demand forecasting, production planning and scheduling, they, however, do not shed light on the entire gamut of activities where joint collaboration is possible by supply chain partners.

We found that only the following four studies empirically measure SCI based on three dimensions – internal integration, external integration with supplier and external integration with customer: Narasimhan and Jayaram (1998), Frohlich and Westbrook (2001), Rozenweig et al. (2003), and Vickery et al. (2003). There are three major limitations in these studies. First, most of these studies with the exception of Frohlich and Westbrook (2001) tried to measure each dimension of integration by just one measurement item. It is well established that the psychometric properties of the overall construct SCI will be substantially improved by measuring each of the three dimensions using multiple items. Second, most of these studies measure only the degree to which focal firms adopted each of the three dimensions of integration – supplier integration, internal integration and customer integration. This implies that their unit of analysis was a focal firm. They did not measure the degree of integration along a supply chain by using an upstream dyad or downstream dyad as the unit of analysis. Finally, none of these studies with the exception of Frohlich and Westbrook (2001) identified any areas of collaboration between supply chain partners.

Frohlich and Westbrook (2001), however, focus on a few areas of integration between supply chain members. Frohlich and Westbrook (2001) define SCI as a function of direction and degree, where the directional aspect (called the arc of integration) captures whether integration exists within the organization and with supplier or/and customers. Accordingly, they define five arcs of integration ranging from an "inward - facing internal" focus to an "outward- facing supply chain" focus. The degree aspect captures the extent to which organizations collaborate and coordinate their activities. They focus on a few areas of joint activities such as sharing of resources and information.

Studies in inter-organizational relationship literature also conceptualize constructs similar to supply chain integration. Heide and Miner (1992) conceptualize cooperation between a firm and its suppliers in the areas of joint problem solving, mutual adjustments and restraint in use of power. This multi-dimensional construct appears to be very similar to supply chain integration. Heide (1994) proposes bilateral governance as an inter-organizational form, which is also similar to the notion of supply chain integration. He concludes that bilateral governance depicts intertwining of roles, joint planning, and mutual adjustments by partners involved in exchange activity. Bensaou (1997) defines inter-organizational cooperation as the degree to which focal activities to the relationship are carried out jointly. It appears that the inter-organizational

relationship literature uses terms such as "cooperation" and "bi-lateral governance" that are conceptually similar to supply chain integration. These three studies, however, focus on cooperation between the firm and its suppliers only. Also, none of these studies identified possible areas for cooperation in realm of supply chain management.

Studies in strategy literature also conceptualize constructs similar to supply chain integration. Mohr and Spekman (1994) test the relationship between certain attributes of strategic partnership of firms with immediate suppliers and business performance. These strategic partnership attributes include coordination and joint problem solving. Pilling et al. (1994) propose "relational closeness", a concept similar to supply chain integration. They view "relational closeness" as an alternative mode of governance, which is in between the markets and hierarchies. "Relational closeness" refers to the degree of joint action by the partners involved in the exchange activity. Zaheer and Venkaraman (1995) propose "relational governance" as an alternate form of governance mode. The notion of supply chain integration is similar to relational governance mode. This governance mode falls in between in the continuum of traditional markets and hierarchies. They conceptualize "relational governance" along two dimensions: quasi-integration and degree of joint action in the exchange relationship. Takeishi (2001) discusses external coordination by Japanese firms with their suppliers. He conceptualizes external coordination with suppliers as joint problem solving efforts with suppliers and frequent communication between the firm and its suppliers. In summary, strategy literature discuss terms similar to supply chain integration such as "coordination", "partnership", and "relational governance". Just like inter-organizational relationship literature, they also emphasize joint actions by partners in exchange relationship. They, however, did not identify the areas for coordination and partnerships in the realm of supply chain management. Also, most of the studies in this stream measure constructs similar to external integration between a firm and its suppliers only.

It is clear from the above review of literature that different streams try to measure the construct of supply chain integration or constructs that are similar to that. However, there are three major limitations in the prior studies. First, none of the studies adequately sheds light on the joint processes where supply chain partners can cooperate and coordinate in order to reap the benefits of integration. Second, most of the studies in the operations management literature use a single measurement item to validate each dimension of supply chain integration. Third, most of the studies in strategy and inter-organizational relationship literature consider only relationship between a firm and its suppliers.

We address aforementioned limitations in this study by coming up a new measure of supply chain integration. Also, we follow the lead of Frohlich and Westbrook (2001) and propose that supply chain integration is a function of both direction and degree. The directional aspect captures whether integration exists within the organization (called internal integration) and with supplier or/and customers (called external integration with suppliers and customers). The degree aspect captures the extent to which supply chain players collaborate and coordinate their activities jointly. We identify the areas where supply chain players collaborate and coordinate their activities jointly and empirically validate the measures.

NEW MEASURE OF SUPPLY CHAIN INTEGRATION

Measuring supply chain integration involves investigating multiple business units that are part of a supply chain. Viewing a supply chain as a series of interconnected customer-supplier relationships allows us to use dyads as unit of analysis and assess the level of integration at the dyadic level in this study. Adapting a concept form Hutchinson's model (1987) we define a supply chain from the vantage point of the central business unit and conceptualize it as a collection of three units – a business unit (central player in a supply chain), its most critical first tier external supplier and its largest first tier external customer. By "most critical first tier external supplier" we mean the supplier unit that is legally independent from the central business unit and supplies the most essential component part or supplies for a major end product produced by the central business unit. Likewise, the "largest first tier external customer" refers to the external customer unit that is legally independent from the central business unit and purchases a major end product from the central business unit in terms of dollar value (adapted from Dong, Carter and Dresner, 2001).

Accordingly, and consistent with Frohlich and Westbrook (2001), the construct Supply Chain Integration is defined as a composite of internal integration (within the business unit) and external integration (with suppliers and customers). Thus SCI is modeled as a second order factor comprised of three dimensions: external integration with supplier, external integration with customer and internal integration.

External integration with supplier is defined as the extent to which the central business unit and its most critical first tier external supplier undertake joint initiatives in the areas of product design, development, capability improvement, order fulfillment, resource sharing and problem solving.

External integration with customer is defined as the extent to which the central business unit and its largest first tier external customer undertake jointly initiative in the areas of product design, development, capability improvement, demand forecasting, resource sharing and problem solving.

The degree of external integration with supplier and customer are both measured based on the responses from the central business unit in line with prior operations management studies (Frohlich and Westbrook, 2001; Vickery et al., 2003; Rosenzweig et al., 2003).

Internal integration is defined as the degree of cross-functional working between departments in a business unit. The degree of internal integration is measured based on responses from the central business unit and the downstream business unit only.

(References and remaining paper available upon request from corresponding author)

Information Transparency in the Big Tent: Is There Room for SMEs?

Introduction

Supply chain (SC) research shows that information transparency increases profits for SC members. Suppliers' access to detailed information on customers' inventory levels, ordering points, replenishment lead times, and reasons for atypical orders enables suppliers to make decisions that diminish the likelihood of the bullwhip effect and vicious cycles. To date, empirical evidence of these relationships has been restricted to those involving supply chain partners with dominant industry positions (e.g., WalMart, Proctor and Gamble) while examples of firms without this kind of dominance are rare.

Transparency of information necessitates information systems that provide data to all SC members. While larger firms possess the financial and other means by which to obtain at least a modicum of technology, smaller firms are far less likely to invest in leading edge technology. As information is most valuable when all SC members have lenses with which to view it and opacity for some members impacts the entire SC as a whole, attention paid to the smaller members of the chain will benefit the entire chain.

This research will analyze the dearth of existing research on supply chain information transparency effected by information technology as it impacts smaller manufacturing enterprises (SMEs) and recommend frameworks for applying extant research to SMEs.

By the late 1990s large firms had achieved supply chain integration via EDI while small and medium sized firms (SMEs) were still using paper (Smeltzer, 2001). Reasons for this are due to the differences between large firms and SMEs: SMEs are unlikely to have sophisticated coordination and control processes; the cost of new expensive information systems (IS) can be

spread over more units of production in large firms; and large firms are more likely to have internal IS development and maintenance capabilities. But as a chain is only as strong as its weakest link and because even large company's supply chains typically include at least 80% SMEs, connectivity among all members is critical to the chain's overall success. One limitation appears to be unrealistic expectations regarding what such connectivity would look like for an SME: "documents containing sophisticated business rules to be built and modified in minutes…by nonprogrammers…posting, extraction, and validation of data in and out of a multitude of systems without rework or downtime…no additional investments in hardware, software, or human resources…don't need to invest in developing, maintaining, and supporting complex systems…upgrades elegantly managed such that changes made in one place can automatically ripple throughout the entire network…when technologies are upgraded from one version to the next version there can be no system downtime." (Smeltzer, 2001) Given such pie in the sky IS requirements, it is no wonder that SMEs have not been fully integrated into electronic supply chains.

However, electronic communication links can reduce the cost of coordinating both economic transactions and production. Moreover, a direct correlation exists between increasing use of information technology and reduction in average firm size (Brynjolfsson, 1990). Firms are then expected to move away from the vertical integration that reduces the need for trust between partners and into greater outsourcing and partnerships (Croom, 2001), thereby extending the length of the supply chain and increasing its membership.

The "bullwhip effect" (Lee, 1997b, , 1997a) occurs when demand is amplified as orders progress up a supply chain. McCullen and Towill (2002) showed that a 5% fluctuation in demand at the customer order point is doubled at each stage of the chain as each firm frames its own demand

forecasts. The result is a 40% fluctuation only three stages removed from the customer. Delays in the timing of information receipt, typical of opaque supply chains, intensifies the bullwhip effect (Akkermans, 2004) as does gaming (Akkermans, 2004; Akkermans, 1999; Lee, 1997a). Information systems enabling all chain members to simultaneously receive the same information about current order and production statuses as well as plans and forecasts will dampen these fluctuations (Akkermans, 2004; Gavirneni, 1999; Kim, 2006; Lee, 1997a). Implementations of these systems, including supplier access to point of sale data, vendor managed inventory, and continuous replenishment programs have been very successful for Wal-Mart, Campbell Soup (McKenney & Clark, 1994), and Barilla SpA (Hammond, 1994).

Given the clear need for transparency of information throughout the entire supply chain, as well as the limitations inherent in being a small, non-dominant firm, is it possible for a supply chain's SMEs to implement this kind of visibility and reap the benefits of shared information with supply chain partners? If so, academic research should reflect the use of information technology by SMEs within a supply chain.

Literature Review

The value of information sharing has been established by prior research (Baiman, 2002; Cachon, 2000; Chu, 2006; Gavirneni, 1999; Gunasekaran, 2004; Lee, 1997b, 1997a). This prior research encompasses traditional information (Axsater, 1993; Moinzadeh, 1986; Svoronos, 1988) and full information (Chen, 1997; Graves, 1996; McGavin, 1993), with full information shown to be optimal by both Chen (Chen, 1994) and Graves (Graves, 1996). Both stationary retailer demand (Aviv, 2003; Bourland, 1996; Gavirneni, 1999) and autoregressive demand (Dong, 2003) have been studied as has sharing of demand forecasts (Aviv, 2001). Among the benefits cited are improvements in customer service, purchasing, forecasting, central planning, and logistics

management as well as increases in inventory turns and return on assets (Gunasekaran, 2004). Others have suggested that, while research tends to focus on the efficacy of IT in enhancing collaboration, it is the nature of the existing relationships, including information sharing, that determine the efficacy of IT (Chae, HsiuJu, & Chwen, 2005).

While valuable, information sharing is hindered by cost (Chu, 2006), tradition (Bowersox, 2000), and lack of faith in the information provided (Radhakrishnan, 2005). Balance of power is critical to information sharing (Bowersox, 2000; Lamming, Caldwell, Phillips, & Harrison, 2005; Radhakrishnan, 2005) as the greatest benefit accrues to those with greatest bargaining power (Radhakrishnan, 2005).

One way to level the playing field is through increased communication among supply chain partners. Information technology (IT) reduces costs of communication (Malone, 1994), coordination, and risk (Clemons, 1992, , 1993) making possible the dissemination of demand information throughout the supply chain, irrespective of its geographical dispersion (Timmer, 2005). Web platforms facilitate the propagation of information in the developed world as minimal hardware and software investments are required to achieve real-time access to non-redundant data and functionality. Ngai et al (2004) found five critical success factors for implementation of a web-based supply chain management system: communication, top management commitment, training and education, data security, and hardware and software reliability. These factors are not unique to web based systems but are common to all successful IT implementations in firms of all sizes.

Lancioni (Lancioni, 2000) found significant differences between large and small firms' use of the web for supply chain management. Larger firms were more likely to use the Internet for purchasing from online catalogs and rating vendors' on time performance; smaller firms tended

to be more interactive in their use of the web, communicating with vendors on finished goods inventory levels, out of stock situations, and price quotes. While research on the use of technology by large multinational U.S. firms has been extensive, research on SMEs has been limited. Because small businesses are responsible for about 50% of U.S. non-farm GDP, research in this area is of paramount importance.

Prater and Ghosh (Prater, 2005) addressed the challenges of SMEs in the context of their model of U.S. firms' global operations experience, strategy, structure, and IT coordination. Kuo, Chen, and Smits (Kuo, 2005) found information systems, information sharing and performance metrics all help smooth the way for synchronization of operations and performance improvement in SME-based collaborative SCM. Dimitriadis and Koh (Dimitriadis, 2005) studied a localized economy in Greece and found IS of critical importance in enhancing information exchange with external SC members. Ho, Trappey and Trappey (Ho, 2004) describe implementation of an XML-based prototype for aerospace SC integration with an emphasis on smaller suppliers. Sakaguchi, Nicovich, and Dibrell (Sakaguchi, 2004) developed a model to guide successful SC integration for SMEs while Robeiro and Love (Robeiro, 2003)detailed two case studies of e-business adoption in the construction industry and suggest ways SMEs can leverage technology. With 80% of all SCs including at least one SME, attention to this sector is of critical importance in SC optimization. If previous research on improvements in SC performance due to greater information visibility were extended to include SMEs, would the benefits of these improvements be overshadowed by missed opportunities for enhanced SC profitability?

If American industry has adopted the premise that a supply chain is only as strong as its weakest link, then the prevailing practice of every company for itself in using technology to enhance SC performance is at odds with the overarching goal of overall SC profitability.

The current research examines the potential missed opportunity for SC improvements inherent in an overwhelming focus on larger firms' IT activities, while neglecting the impact of lack of IT among SME SC partners.

Methodology

A meta analysis of existing research on information systems in supply chains reveals limited attention to SMEs. The meta analysis was conducted by searching electronically accessible (EBSCO) peer reviewed academic journals for abstracts containing the words "supply chain" and either "information technology" (224) or "information systems" (109) among articles published between 2002 and 2006 inclusive. Some articles appeared in both searches, reducing the total number of articles retrieved to 304. These abstracts were then scanned for inclusion, based upon whether they discussed both supply chain and information systems/technology as integral to the research or simply referred to either of the terms as a future research direction or other equivalent non-pertinent context. The remaining 171 articles were then categorized based upon whether the research either explicitly or implicitly includes SMEs.

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